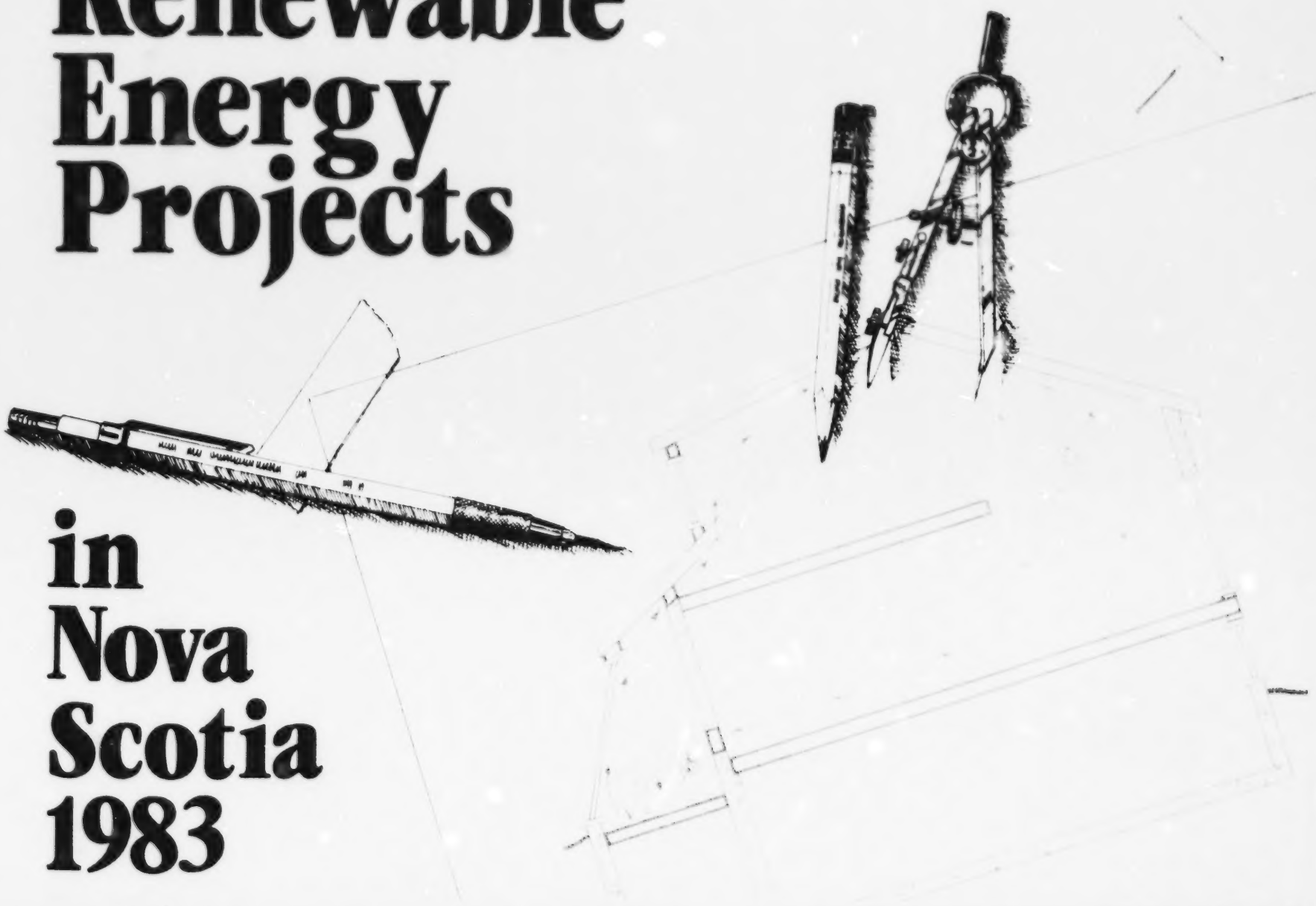
Energy Mines and Resources Canada
Énergie, Mines et Ressources Canada
Nova Scotia Department of Mines and Energy

Renewable Energy Projects in Nova Scotia 1983



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Introduction

Renewable energy and energy conservation are two important elements in reducing our dependence upon diminishing supplies of increasingly costly fossil fuels. When used together, renewable energy and energy conservation may provide a large measure of independence from conventional energy sources. By practicing energy conservation, we can restrict our demand for energy to a fraction of our former needs. By using renewable energy, we can eliminate much of our dependence on fossil fuels.

The Small Scale Energy Demonstration Program was initiated in the fall of 1980 to assist Nova Scotians with the demonstration of renewable energy and innovative energy conservation technologies. Applications were accepted from individuals, businesses, and community groups. Proposals were judged by a panel of independent judges, each having extensive experience in renewable energy and conservation technologies. The best proposals received offers of funding. The maximum grant available was $10,000.

The response to the program was so enthusiastic and the quality of the proposals so high, that the program was repeated in 1981, 1982 and 1983. More than 1,000 proposals were received during the four competitions, and about 300 projects were offered assistance.

The program was designed to achieve four distinct objectives:

1. increase the design and installation skills of Nova Scotians with renewable energy and energy conservation technologies,

2. improve community understanding of the technologies by sharing knowledge gained,

3. hasten the development of renewable energy and conservation in Nova Scotia,

4. gather information on the economics and dependability of individual renewable energy and conservation projects.

The number and diversity of projects assisted has assured that our first objective has been met.

This book, efforts of project owners to share their knowledge, media coverage of the program, and other information available on the Small Scale projects has accomplished our second goal.

The number of renewable energy and innovative conservation projects in Nova Scotia is much greater now than before the inititation of the program, bringing us within reach of our third objective.

Finally, the governments who have sponsored this program are now better able to assess renewable energy and new conservation technologies.

Renewable energy sources used in these projects were solar, wind, hydro and biomass. Conservation was represented mainly by energy efficient housing innovations.

The more promising technologies identified were passive solar heating, attached solar greenhouses, solar domestic hot water heating, and a number of energy efficient housing design improvements. These technologies, as represented by numerous projects, have potentially wide application in the housing market. Their relatively low cost, small or non-existent operating cost, aesthetic value, and long-life make them attractive options for the homeowner or home builder.

Over the last few years, heating equipment that burns round or chunk wood has played an important part in reducing Nova Scotia's dependence on imported oil. Since this "biomass combustion technology" is well understood and is widely used in Nova Scotia, there was little need for this technology to be demonstrated under the Small Scale Energy Demonstration Program.

This publication is intended to provide readers with an overview of the demonstration projects completed, a summary of the construction methods used, information on each project's performance, reliability, and economics. Unfortunately, most of the projects have not yet been in operation long enough to provide detailed performance information.

The book is also a tribute to the many Nova Scotians who have invested their time and money in the projects described, or who have completed similar projects without government assistance. The enthusiasm and dedication of these people and the quality of the completed projects has already given rise to similar projects among other members of their communities. It is hoped that this book will accelerate this trend.

Editor's Note

This publication and the Small Scale Energy Demonstration Program were funded 80 per cent by Canada and 20 per cent by the Province of Nova Scotia under the Canada/Nova Scotia Agreement on Energy Conservation. The agreement is administered on the federal side by Energy, Mines and Resources Canada and by the Nova Scotia Department of Mines and Energy on behalf of the province.

All projects assisted by the Small Scale Energy Demonstration Program are available for public viewing. Terms of the assistance ensure that project owners must permit *reasonable* access to the project for a three year period, starting from completion of the project.

The project descriptions contained in this publication were compiled during late 1981 and 1982. Project status has undoubtedly changed in a number of cases and some projects described as incomplete in this publication are now finished.

Solar Domestic Water Heating

1

Using the sun's rays to heat water for domestic use is quickly becoming the most popular application of active solar energy in Nova Scotia. The reason is that solar domestic water heating (DHW) systems have some very distinct advantages:

- Solar DHW systems have a low capital cost compared to other solar or renewable energy applications. (The exception to this is wood heat, which can be very economical.) Solar DHW systems can provide hot water year round and meet about 60 per cent of a family's annual hot water demand. Other solar DHW systems only operate from early spring to late fall. However, these seasonal systems must be drained in fall to prevent freezing, and refilled each spring. Because they operate during the months of maximum sunshine, they can still provide about 80 per cent of the hot water supplied by a system operating year round. Solar DHW systems may be purchased from a number of Nova Scotian manufacturers and suppliers.
- Unlike solar space heating systems, which are inactive when the sun is at its best, solar DHW systems can operate all year, taking advantage of peak summer sun.
- The technology, aside from collector design and construction, is within the capacity of most people to understand and use. Even collectors can be successfully constructed by the novice, although these often end up less efficient than the commercial products.
- Solar DHW systems are easily coupled with electric, wood, propane, or oil-fired hot water heating systems to provide a continuous supply of domestic hot water.
- The typical solar DHW systems consist of one or more solar collectors; a heat transfer medium (water, or antifreeze); a pump or other method to circulate the transfer medium to the collectors and back; one or more differential thermostats; storage capacity; and a heat exchange mechanism for transferring heat from the collection medium to the domestic water.

The collector is the heart of the solar DHW system. It is simply a device for capturing the sun's radiant energy. Generally it consists of an absorber plate (made of aluminum, steel or copper sheet) inside a shallow box. The plate, which is usually painted black or covered with a special coating, absorbs solar radiation and converts it into heat.

One side of the box has a transparent cover made of either glass or plastic. To maximize efficiency, this cover should allow maximum radiation in and prevent radiation and heat from escaping. Glass allows less heat loss and has a longer life than most plastics. Plastics, however, are cheaper. Some, but not all, even transmit more radiation.

The optimum glazing material should have high solar radiation transmission, low thermal conductivity, and low thermal radiation transmission. It should also be affordable and resistant to decay, fire and decomposition.

The domestic hot water heating systems described in this publication all use a liquid as a heat transfer mechanism. In systems designed for year-round use, non-toxic polypropylene glycol is mixed with the water to produce a heat transfer medium that will not freeze and may be used year round. Another method of freeze protection is used in *"drain back"* systems. Water is used as the heat transfer medium. In these systems, the water automatically drains back to the storage tank whenever the temperature is near freezing.

Solar collectors vary in their efficiency, the amount of useful energy they deliver relative to the amount of solar energy available. An accepted procedure for measuring collector efficiency is the ASHRAE 93-77 test. Results of this test are available on almost all solar collectors sold commercially.

The solar DHW projects we describe are quite varied. They encompass a variety of solar collector designs, several fluid circulation methods, a number of heat exchange mechanisms, and a range of water storage systems.

Examples of a simple solar DHW system containing no controls or pump are those built by Harvey Eldridge and James Hardy.

In these typical thermosyphon systems, water circulation takes place naturally by convection. As water is heated in the collector, it becomes less dense and rises to the storage tank, which must be placed above the collector. The heated water is replaced by colder, heavier water, forcing the warm water to the top of the storage tank. With the tank above the collector, water will continue to circulate as long as sufficient solar energy is available to heat the colder water drawn from the bottom of the tank.

The system heats the water that is used for domestic purposes, eliminating the need for a heat transfer mechanism. However, this system

cannot be used during periods of freezing temperatures.

The system developed by Dr. David F. Goble also relies on non-mechanical transfer of heat from the collector to the storage tank. In this system, a heat pipe transfers heat from the collector to storage. Unlike the thermosyphon system, it can be used year round.

The solar DHW system installed by David Harris and Louise McKenna is also suitable for year-round use. It has two small pumps controlled by thermostatic sensors. One pump circulates the antifreeze solution through the collectors while the other circulates the domestic water through the heat exchanger.

A year-round *"drain back"* solar DHW system using only one pump was installed by Wayne Bhola. In this system, the storage tank for the solar heated water surrounds the tank containing the domestic water. Heat is transferred from the solar heated water through the tank's adjoining wall. A pump, controlled by thermostatic sensors, circulates the solar heated water between the collector and the storage tank when the sun is shining and the collector temperature is above freezing.

The system installed by Murdy Conlin uses water rather than antifreeze and yet is protected from freezing by draining the collector at low temperatures. Water automatically drains back into the storage tank rather than remaining in the collector and freezing. A pump circulates the water between collector and storage tank whenever the collector temperature exceeds the temperature of water in the tank.

In summary, solar domestic hot water heating is technically proven, can be accomplished using a variety of equipment configurations from the simple to the complex, can be easily twinned with a variety of other energy sources, and is relatively cost-free once installed. Its major drawback is its high capital cost in comparison with conventional domestic water heating systems.

Home-Built Solar Domestic Hot Water Heater

Peter Allen
Halifax, Halifax County

Purpose:

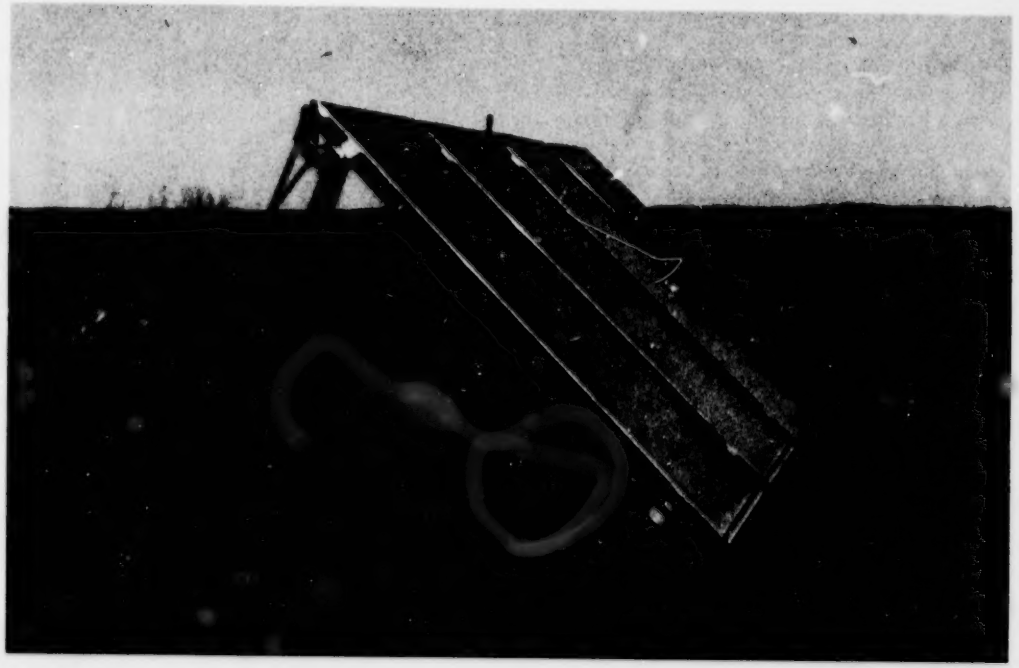
The solar hot water system will heat or preheat domestic hot water for Mr. Allen's family of four. It will also serve as the first demonstration of the solar panels which Mr. Allen manufactures. The unit will be fully monitored over a one-year period to determine its performance.

Description:

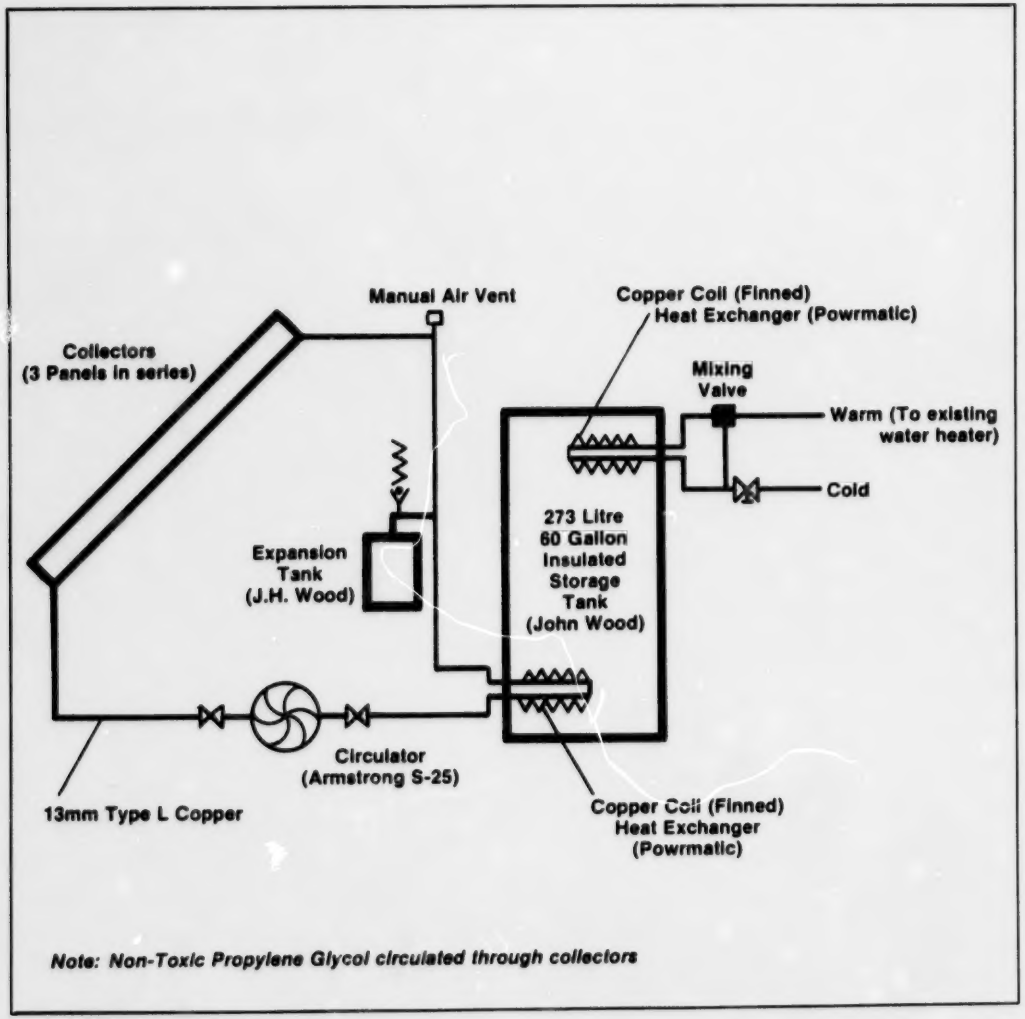
Mr. Allen has set up a small business to manufacture his solar collector panel. Each collector has a copper absorber plate with a selective black paint. The collectors are mounted inside an insulated aluminum box with a low iron glass single glazing.

To construct the collector, 13 mm (1/2 in.) rigid copper tubes are soldered to narrow strips of copper which fit snugly against the tubes. The array of copper tubes is then soldered to larger header pipes which can be prepared for either parallel or series flow connections. This absorber is then painted with a selective paint giving better performance than flat black, but not quite as good as electroplated surfaces.

An aluminum frame is made from 100 mm (4 in.) U channel aluminum with mitered



Solar Collector Manufactured by Peter Allen



Solar Assisted Hot Water System

corners for a clean fit. A thin aluminum sheet is fastened to the back of the box and the frame is insulated with foil backed, rigid fibreglass.

The absorber plate assembly lays on top of the insulation. A locking rubber seal holds the low iron glass in place and seals out moisture.

Mr. Allen has mounted four of these 2.4 m^2 (26 sq. ft.) collectors on a wooden frame on the roof of the house. The collectors are connected in parallel and filled with a glycol solution. A circulating pump, storage tank, differential controller, and heat exchanger complete the active system.

The heat exchanger coil is mounted inside a stainless steel preheat tank. Supply water enters a preheat tank and passes through an electric hot water heater where it is further heated, if required.

Thermocouples, and flow meters are incorporated into the system to enable Mr. Allen to monitor the performance of his collectors.

Performance and Economics:

It will take Mr. Allen approximately one year to determine the performance of this system. The early *"bugs"* have already been identified and corrected.

Mr. Allen buys the materials for his collectors in bulk, at greatly reduced costs. As of the spring of 1983, he is selling his 2.4 m^2 collectors for about $450 each, a very good price for the quality of the unit.

Viewing:

Call Mr. Allen at home **(443-3638)** to make arrangements if you are interested in seeing his solar system.

Solar Domestic Hot Water Heater

George Balcom
Kingston, Kings County

Purpose:

The solar heating system will heat the domestic hot water with a minimum of assistance from an electric water heater. A drain back system for year-round operation was selected and sized to provide enough hot water for a small family.

Description:

The "Petro-Sun" drain back system is a dual tank, open-loop system that uses a small drain back tank with a 370 L (80 gal.) electric hot water tank, a single-wall internal copper tube-and-fin heat exchanger, and a preplumbed and prewired control package. The system is open to atmospheric pressure. Gravity drains the collector, preventing the water from freezing.

The Model DB-100 system has four collector panels, each measuring 914 mm x 2,438 mm (3 ft. x 8 ft.). The collectors have a black chrome selective surface coating on the tube-and-plate absorber, low-iron glass single glazing, fibreglass and isocyanurate foam insulation, and an aluminum casing. Two *"Grundfos UP25-6456"* pumps circulate the collector fluid (water) through the collector array while a *"Tuco Model 102B"* pump circulates the domestic water from the storage tank through the heat exchanger. The storage tank is a 370 L (80 gal.) electric hot water tank with two extra connections for circulation through the heat exchanger.

This system is usually installed by the supplier. He, however, went out-of-business. Mr. Balcom had to install the system or delay construction of his home.

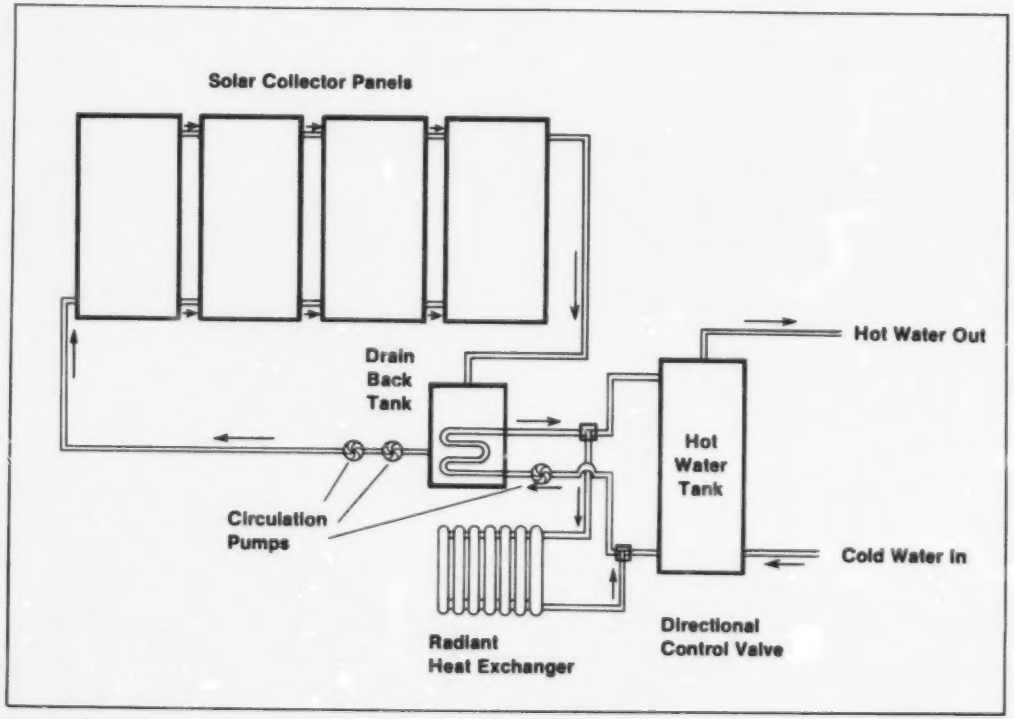
Instead of mounting the collector panels directly on the roof shingles, Mr. Balcom built a metal frame to lift the panels about 150 mm (6 in.) above the roof. Rubber spacers separate the aluminum collector panel frames from the steel mounting frame to avoid galvanic corrosion. Slotted holes on the panels allow for thermal expansion.

The manufacturer specified 95/5, tin/antimony solder on the joints between the collectors, but this would make them inseparable should problems develop. Instead, brass couplings were soldered to the panels, allowing them to be threaded together.

A 25 mm (1 in.) copper pipe connects the collectors to the tanks and controls in the basement. This pipe was insulated with flexible foam insulation.

The differential controller is mounted directly on the preplumbed control panel. Electrical leads run to temperature sensors on the high side of the collector panel and the drain back tank. When the collector panel is 11°C (20°F) warmer than the drain back tank, the two pumps turn on and circulate the water from the drain back tank, through the collectors and back. The high water velocity purges the air from the collectors. Once the purging is complete, one pump stops running. This lessens electricity use, decreases the flow-rate, and improves solar performance.

The third pump circulates domestic water from the electric hot water heater, through the heat



System Schematic

exchanger in the bottom of the drain back tank. This exchanger extracts the heat supplied by the collectors and transfers it to the domestic hot water. This pump comes on four minutes after the collector pumps start and continues for several minutes after the collector pumps stop.

When the temperature of the collector panels drops near freezing or the temperature difference between the collector and drain back tank becomes less than 2.75°C (5°F), the controller stops the circulation to the panels. Once this occurs, the water in the collectors returns to the drain back tank. Only air will remain in the collectors, eliminating the possibility of damage from freezing.

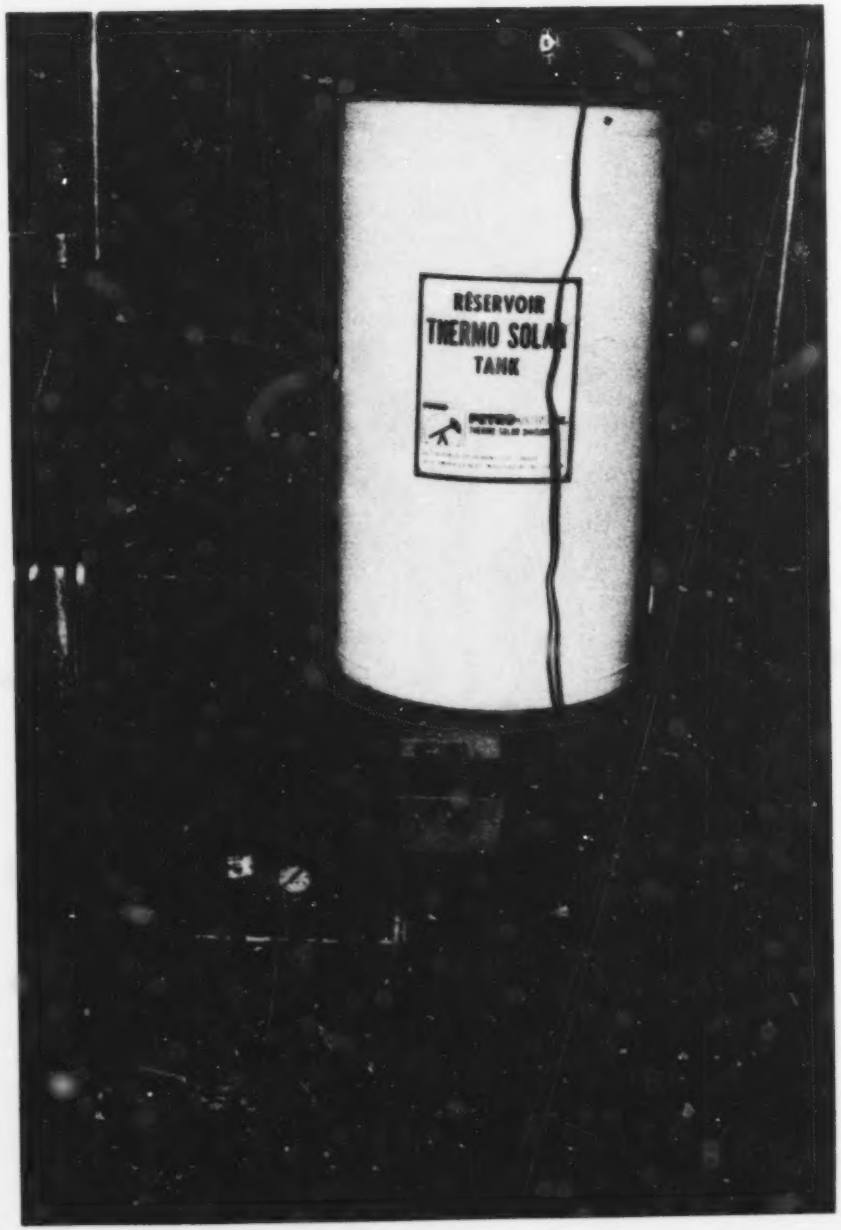
The house was under construction when this report was prepared. The pump for circulating the domestic water was being used to circulate water through a cast-iron radiator. The heat released helped heat the home during construction.

Comments:

Due to problems obtaining materials, Mr. Balcom did not expect the house to be completed until the summer of 1982. When the house is occupied, the solar heating system will be used.

Viewing:

Those wishing to view the solar heating system and discuss it with Mr. Balcom should telephone in advance to make arrangements—**765-4021.**



Pumps, tank, and controls of solar domestic hot water system

Solar Domestic Hot Water Heater

Wayne Bhola
Hilden, Colchester County

Purpose:

The purpose of this project was to build a solar heated domestic hot water system capable of supplying the needs of an average family. The system uses drain back freeze protection.

Description:

Mr. Bhola's collector panel is of novel design and uses new, automotive radiator core tubes. Sixteen of these tubes were soldered together to form a section 200 mm (8 in.) x 1.4 m (4.5 ft.). Headers were made by machining slots measuring 3.1 mm (1/8 in.) wide and 200 mm (8 in.) long in 25 mm (1 in.) copper tubes. The ends of the radiator core tubes were soldered into the header tube slots. The final panel measures 1.4 m x 2.7 m (4.5 ft. x 9 ft.).

The collector panel was placed in a pressure-treated plywood frame. The walls and back of the frame were insulated with a 50 mm (2 in.) layer of foil-backed, rigid foam insulation. The front of the frame has laminated wooden arches. *"Twinwall"* glazing was placed over the arches and fastened to the frame with plastic bolts.

A double walled tank is used for thermal storage and heat transfer. The 182 L (40 gal.) inner section of the tank contains the pressurized, domestic hot water. The 227 L (50 gal.) outer section contains the water circulated through the collector panel. Heat is transferred from the collector water to domestic hot water through the common steel wall. The outside of the tank is insulated with 100 mm (4 in.) of fibreglass and covered with aluminum foil.

When the temperature sensors on the back of the collector panel and the sensor in the preheat tank measure a temperature difference of 8°C (15°F), the *"Delta T"* control switches on the stainless steel *"Grundfos"* pump. The pump fills the collector panel with water from the preheat tank. The water then circulates through the collector and back to the preheat tank. When there is an insufficient temperature difference or when the collector panel temperature is near freezing, the pump stops and the water in the collector drains from the collector panel into the preheat tank.

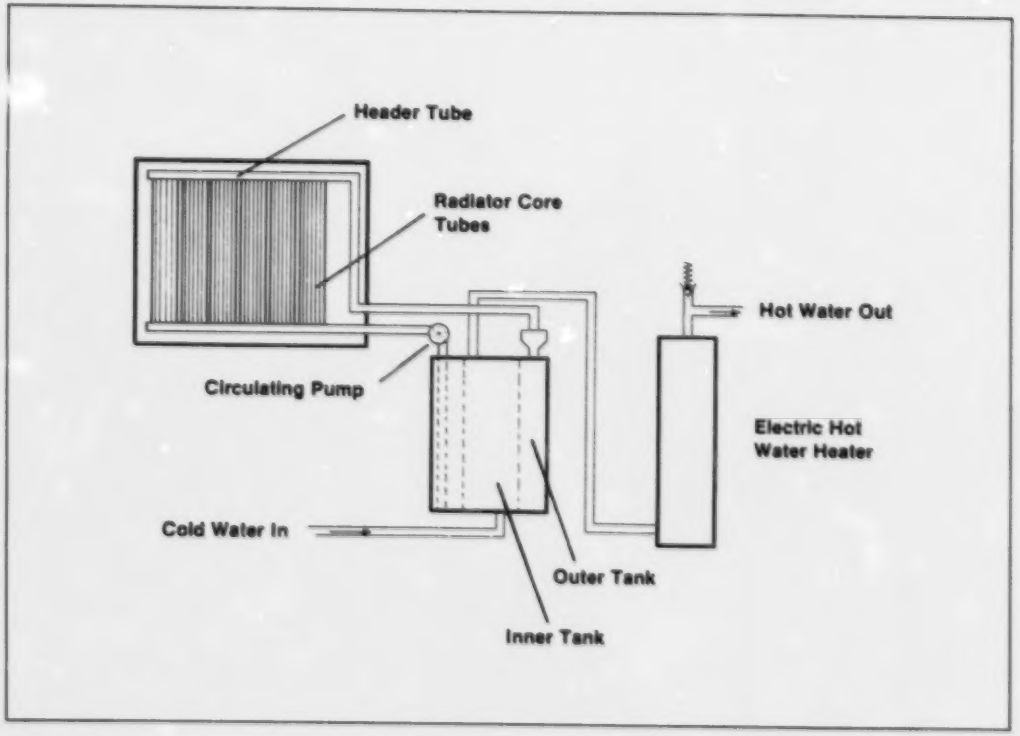
After the domestic water leaves the preheat tank, it flows into the electric hot water heater where it is heated further if required.

Performance:

Following completion, Mr. Bhola plans to monitor eight different temperatures within the system on a continuous basis. A power meter or clock will determine the power consumption of the hot water heater. The information will be used to adjust the system and determine its overall performance.

Economics:

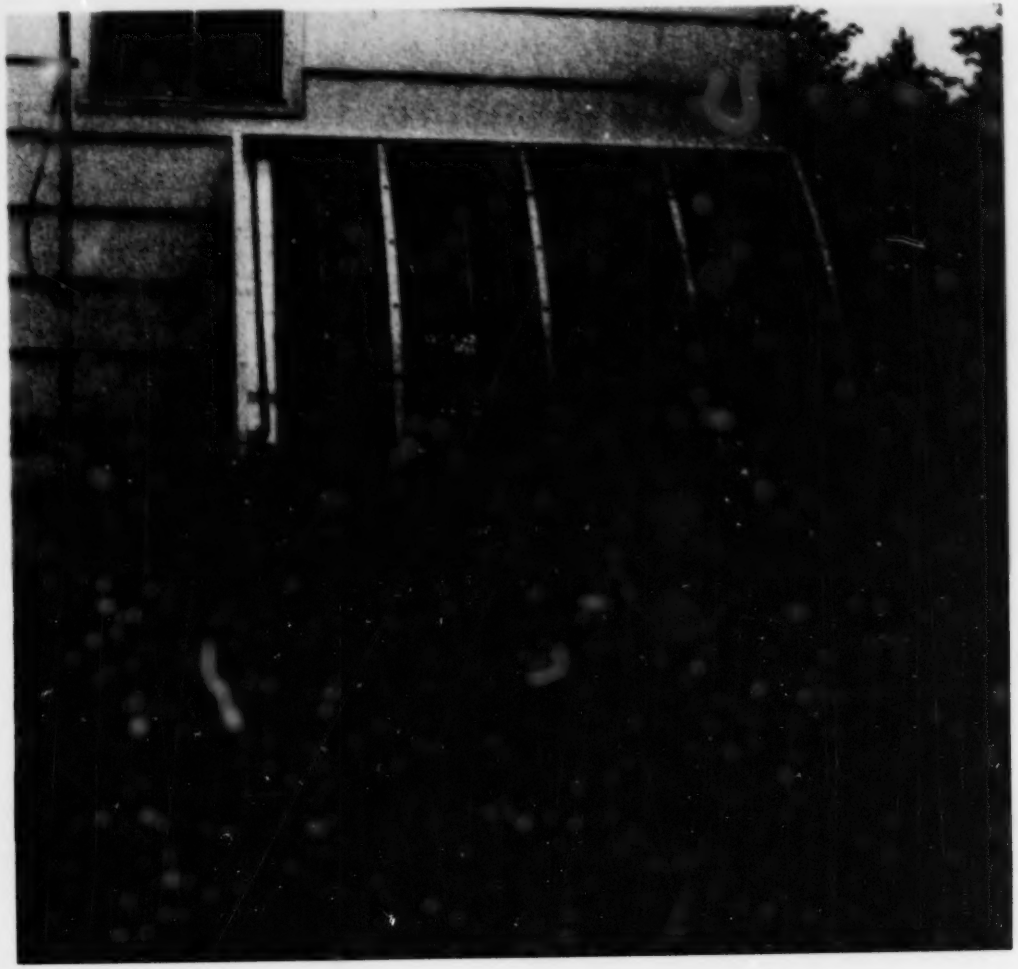
Mr. Bhola hopes the system will provide almost 100 per cent of the hot water heating in the summer and 80 per cent in the winter. If the system performs as expected, it will save about $300 worth of electric water heating per year, a payback of the $1,200 system cost in four years.



System Schematic

Comment:
If the drain back system doesn't perform as expected, a propylene glycol solution can be used to ensure adequate freeze protection.

Viewing:
Those persons interested in talking with Mr. Bhola about his project should telephone **893-8091** to make arrangements.



Wall mounted solar collectors

Solar and Wood Range Domestic Hot Water Heater

A.S. Blanchard
Chester, Lunenburg County

Purpose:

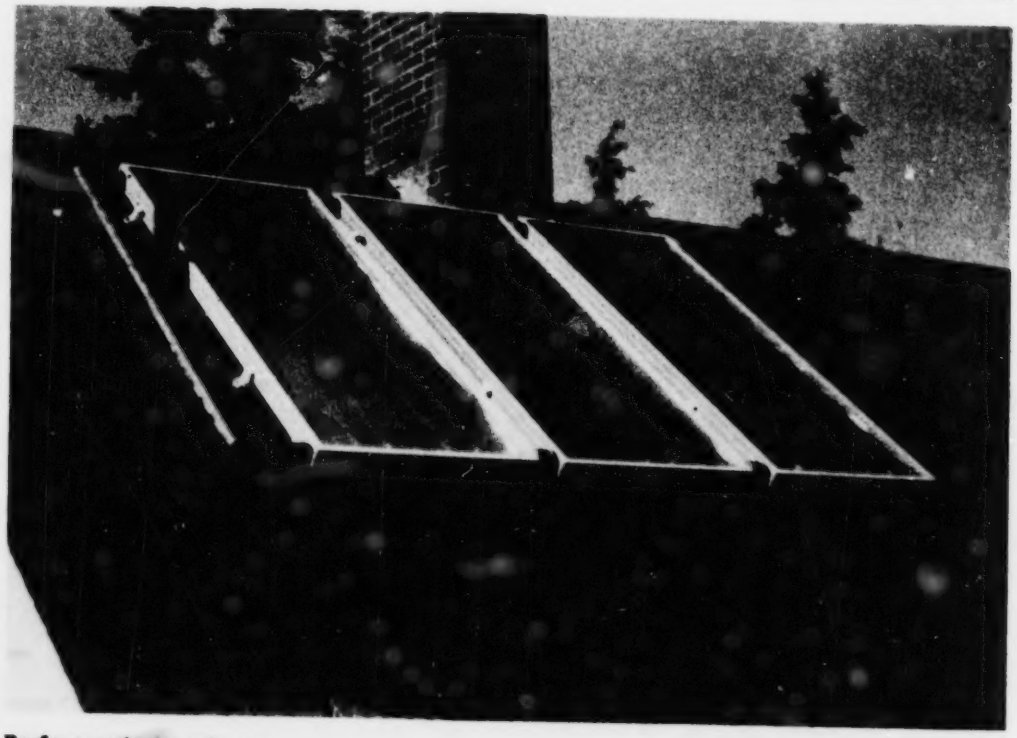
This project will reduce the Blanchard's electricity use by preheating domestic hot water using a heat exchanger inside an existing wood range and a roof mounted solar collector. The wood range will preheat the hot water in winter when the range is normally used for space heating. When warmer weather arrives, the range is not used and the solar collectors will preheat the water.

Description:

Mr. Blanchard's system uses two, 227 L (60 U.S. gal.) preheat storage tanks in series with an existing hot water heater. Three 1.6 m^2 (18 sq. ft.) *"Petrosun"* solar collectors heat the first tank. The collectors are in a closed loop system using a heat exchanger inside the preheat tank and a thermostatically controlled circulating pump. The collector-heat exchanger uses a glycol solution loop to avoid damage from freezing.

The second preheat tank is heated by a heat exchanger in the wood range. A pump circulates water between the range heat exchanger and a heat exchanger inside the preheat tank. Water is the heat transfer medium in this part of the system.

As the domestic hot water is used, it passes from the two preheat tanks into the electric heater where it is heated if required.



Roof mounted solar collectors

Performance:

This system was installed during the spring of 1981 and a full evaluation has not yet been prepared; however, on a clear day in early June, the solar collectors heated the water to about 68°C (150°F)—more than adequate for domestic use.

The wood range seemed equally capable of heating the water to desired levels without assistance. However, problems arose because the three tanks were connected in series. On a sunny summer day, the solar heated water cools as it passes through the second preheat tank and then the electrically heated tank. Plumbing changes will be made to either circulate the water between tanks or to bypass the second and third tank, when possible.

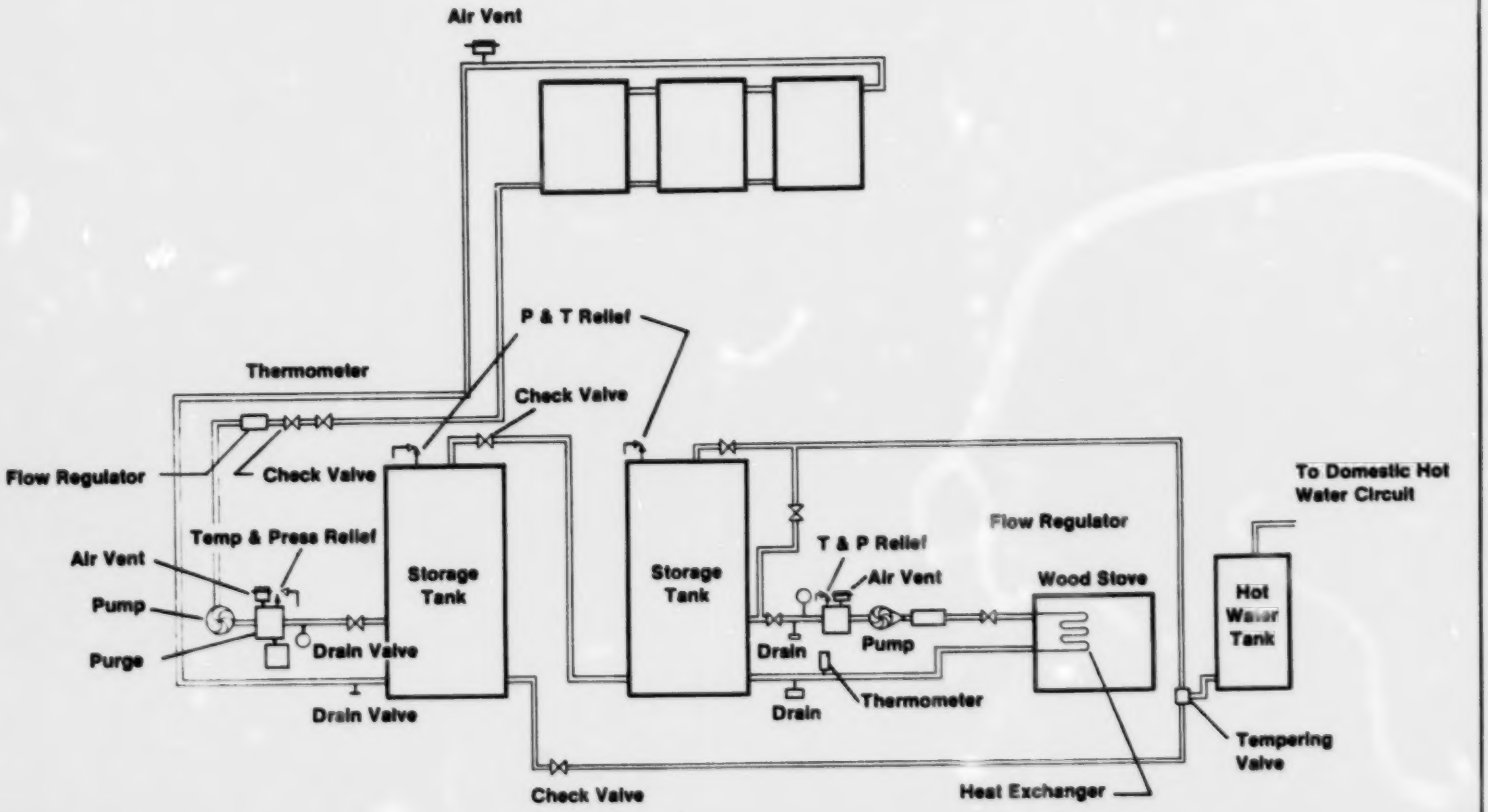
Economics:

The Blanchards have significantly reduced the electrical demands of their family's home. Two wood stoves, a wood range, and a passive solar greenhouse now do most of the heating.

They hope the solar-wood range water heating system will further reduce the electric bill by $350 per year. The total cost of the new system was $5,700. However, this system incorporates very sophisticated equipment and may be oversized. It may be possible to build a similar system for a lower cost.

Viewing:

Visitors are welcome provided they call in advance to make arrangements—**275-4633.**



System Schematic

Solar Domestic Water Heating

William Boutilier
Sydney, Cape Breton County

Purpose:

Mr. Boutilier already built a 19.5 m^2 (210 sq. ft.) flat plate collector system to preheat domestic hot water and provide space heating. This current project increases the system's hot water storage capacity. Mr. Boutilier will monitor the system's performance for one year and will consolidate current and new data to determine its efficiency and output.

Description:

The solar collector system consists of 19.5 m^2 of flat plate collector with 455 g (16 oz.) double glazed glass, having an air space of about 25 mm (1 in.) between the glazing. The collector system has 28 panels made of 560 mm x 1220 mm (22 1/2 in. x 48 in.) galvanized steel with 7.5 m (25 ft.) of 9.5 mm (3/8 in.) copper tubing soldered to the back side. The front surface of the galvanized steel is painted with two coats of flat paint. The first coat is black paint and the second a mixture of green and black. This was found to be a more efficient collector surface than black alone.

Eight rows of collector panels, 4 rows of 4 panels, and 4 rows of 3 panels, are connected in parallel with a header system at the top and bottom, using a unique piping arrangement that prevents air locking and equalizes fluid flow. The collector panels are insulated on the back with styrofoam and fibreglass insulations. Silicon caulking seals the glazing and an air purging system clears moisture from between the layers of glass. The system's copper piping is filled with a mixture of ethylene glycol and water.

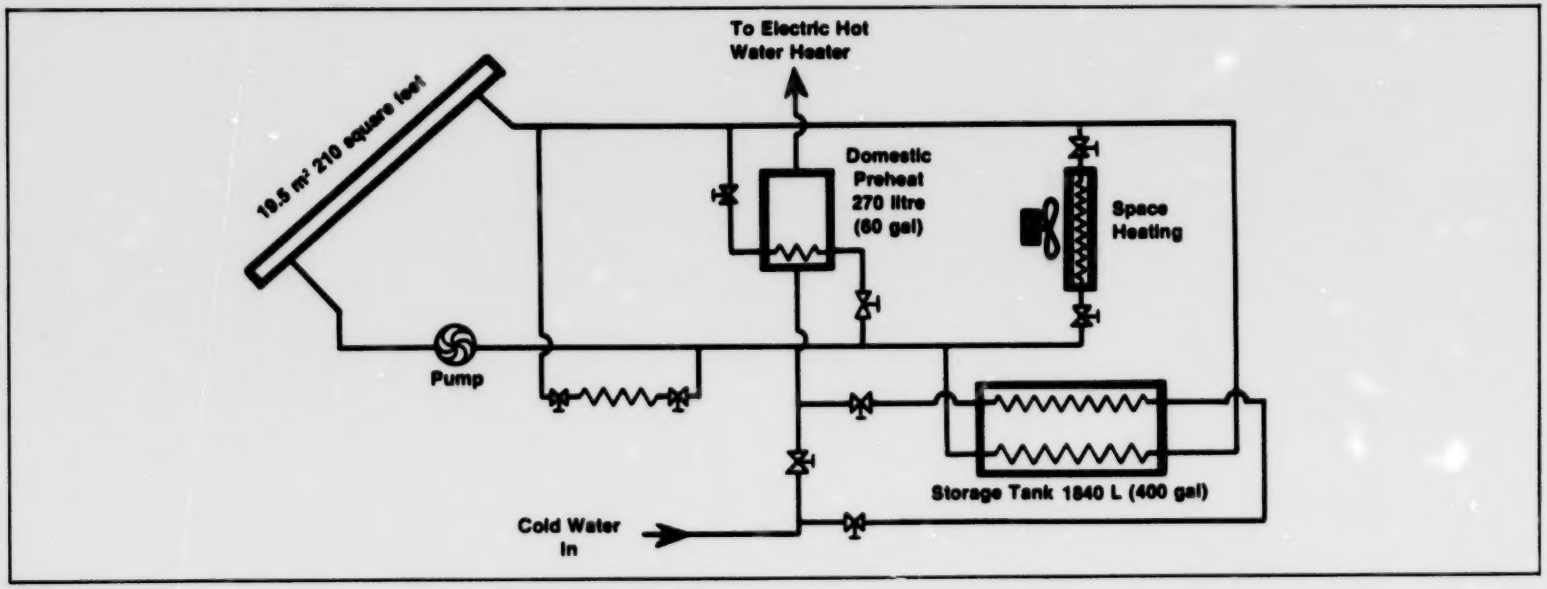
Garage mounted solar collectors

A positive displacement gear pump driven by a 12 volt D.C. generator converted to motor operation pumps the mixture through the system and into the storage and heat exchangers in the basement. The motor's control system provides variable speed operation, dependent on the temperature difference between thermistors on the collector and the hot water storage tank.

The original preheat storage tank is a 270 L (60 gal.) stainless steel unit, connected in series with the electric hot water heater. The heat exchanger is 10.6 m (75 ft.) of 95 mm (3/8 in.) copper tubing inside the tank. An additional heat exchanger provides space heating. This heat exchanger is a surplus refrigeration evaporator with 100V fan behind it. The fan will switch on if the incoming glycol/water temperature is 52°C (125°F) or more and if the thermostat in the house calls for heat.

The additional hot water storage tank is an open top, 1816 L (400 gal.) unit, made from plate steel and covered by two coats of zinc-chromate primer and two coats of enamel metal paint. All junctions between dissimilar metals are electrically insulated with neoprene fitting to avoid corrosion. Styrofoam panels floating on top of the water reduce evaporation.

The collector system sits at a 54° angle atop a garage 4.9 m (16 ft.) long, 4.9 m (16 ft.) wide,



System Schematic

and 5.2 m (17 ft.) high. A feature of this building is that it can be lengthened by adding additional frame sections. The two floor structure has a garage door at one end, and a standard 81 m x 200 m (2 ft. 8 in. x 6 ft. 8 in.) door entrance on the other end along with two windows for ventilation.

The building's ground floor is a reinforced concrete slab, while the second floor is formed by cross bracing between the rafters. This second floor supports the solar panels and provides a dry, warm storage area.

Performance:

The original system heated 60 per cent of the Boutilier family's hot water and provide some space heating. By measuring incoming and outgoing glycol temperatures and flow rates, Mr. Boutilier determined that the system has produced mid-day outputs of up to 30,000 BTU/hour (8800 watts).

Economics:

The original system provided about 3,000 kwh (10^7 BTU) of hot water per year worth about $150. The modified system will provide at least twice as much hot water. The energy provided for space heating, however, is not easily determined. Mr. Boutilier plans to evaluate this in future.

Mr. Boutilier says the original system cost $4,000 in 1977. This includes the garage on which the collectors are mounted. However, if the cost of the garage was not included, another support structure would be required. The additional storage tank cost $1,000. The Small Scale Energy Demonstration Program Grant was used for alterations and monitoring the performance of the system.

Comment:

Mr. Boutilier emphasizes that a solar project using glass must be very well constructed. First, the foundation cannot shift or crack, otherwise the structure will deform and break the glass. Second, the carpentry must be very accurate. Glass panes cannot be "trimmed" to fit. If you start trimming or bending the wood frame, you will probably end up with a mess. Also, dry, straight wood is essential for a good finished product.

Viewing:

Anyone interested in discussing solar water heating with Mr. Boutilier should telephone him at home, during the evening, to make arrangements—**539-5659.**

Wall Mounted Solar Collectors

Murdy Conlin
Berwick, Kings County

Purpose:

The solar domestic hot water system will reduce the Conlin family's energy costs by preheating water before it enters the conventional water heater. This system replaces a much smaller, less sophisticated system which Mr. Conlin built and operated for three years.

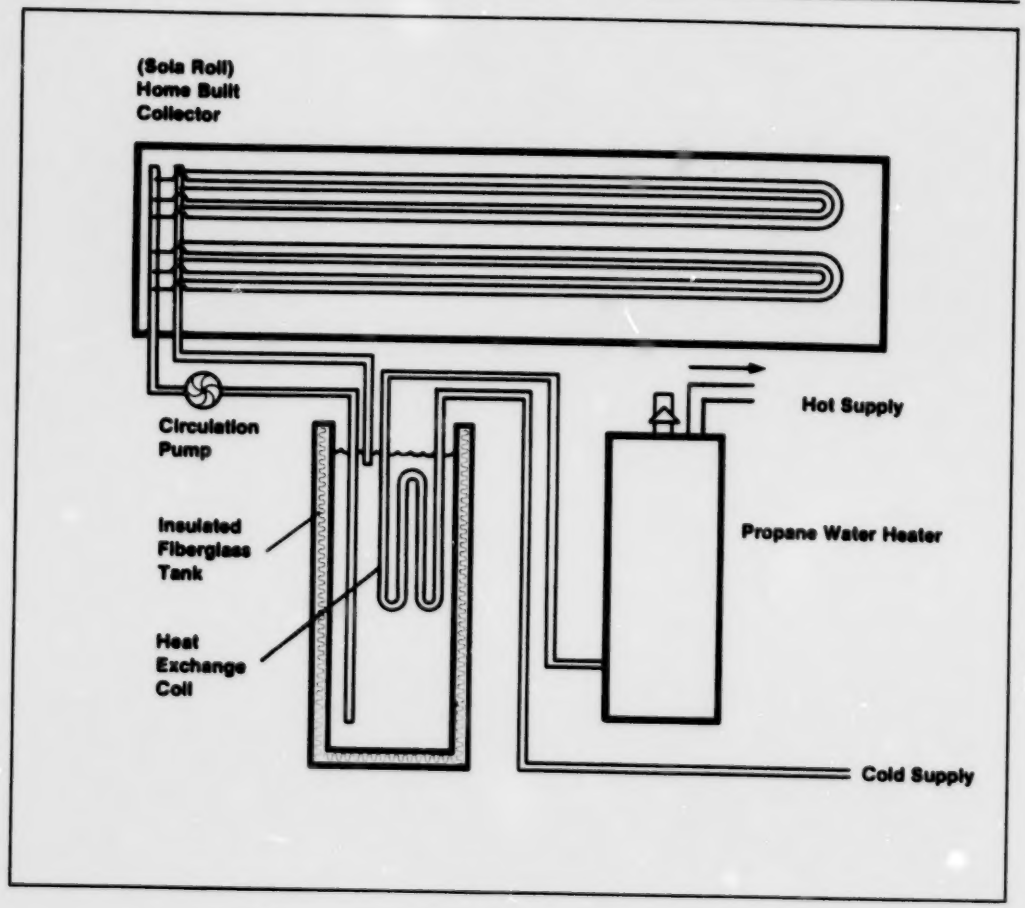
Description:

The heart of the solar hot water system is a collector panel which uses *"Sola Roll"* components. The solar absorber plate material is made of EPDM plastic and comes in a roll, 114 mm (4 1/2 in.) wide and consists of 6 tubes separated by a flat mat.

To construct the absorber plate, a piece is cut from the roll twice as long as your collector panel. A section of the mat is removed between the tubes, in the middle of the cut piece of collector roll. The roll is then bent 180° so that it forms a flat collector 228 mm (9 in.) wide. Lastly, one-half of the tubes are connected to a cold water supply leader and one-half to the hot water return header. Successive sections may be added, side-by-side to produce an absorber plate of the desired width.

To complete the collector, a wooden frame is made of 50 mm x 100 mm (2 in. x 4 in.) lumber and covered with a plywood bank. Mr. Conlin used two layers of *"Aspenite"* separated by a 25 mm (1 in.) layer of foil backed, isocynurate rigid insulation for the back of his collector.

The Sola Roll system comes with a framing strip for securing the glazing to the collector. For a single width collector such as Mr.



System Schematic

Conlin's, the framing strip holds the glazing in place on the front of the collector, covers the sides and folds around the back edge of the panel, producing a very professional looking product.

Mr. Conlin used *"Kalwall"* fiberglass glazing for his 1.25 m x 6.0 m (4 ft. x 25 ft.) collector panel. The Sola Roll framing strip holds the Kalwall securely in place and produces a tight seal.

The collector panel is mounted 50° from the horizontal across the front of the Conlin's two storey house.

The solar heated water is stored in a 460 L (100 gal.) double walled fiberglass tank, manufactured by Legay Plastic Ltd., Waverley. This particular tank is a one piece (except the lid), vertical unit. This eliminates leakage problems common to sectional fiberglass tanks. All pipe and vent connections are through the

removable lid. The 130 mm (4 in.) space between the double walls of the tank is insulated with expanded foam. These tanks can be manufactured to any length.

A single "Grundfos" pump, operated by a differential thermostat, circulates the water through the collector panel and back to the storage tank whenever the collector plate is warmer than the water in the storage tank. All piping is sloped for automatic drain back to the storage tank when the pump stops.

The system has double freeze protection in its drain back operation and in the absorber plate material. Should the drain back system fail and water in the collector freeze, the plastic tubes of the Sola Roll absorber will expand but not rupture.

Cold water flowing to the conventional propane water heater first passes through a furnace type heat exchanger that is immersed in the solar storage tank. The incoming cold water is warmed before it enters the propane heater. The heater brings the water to the desired temperature.

Performance:

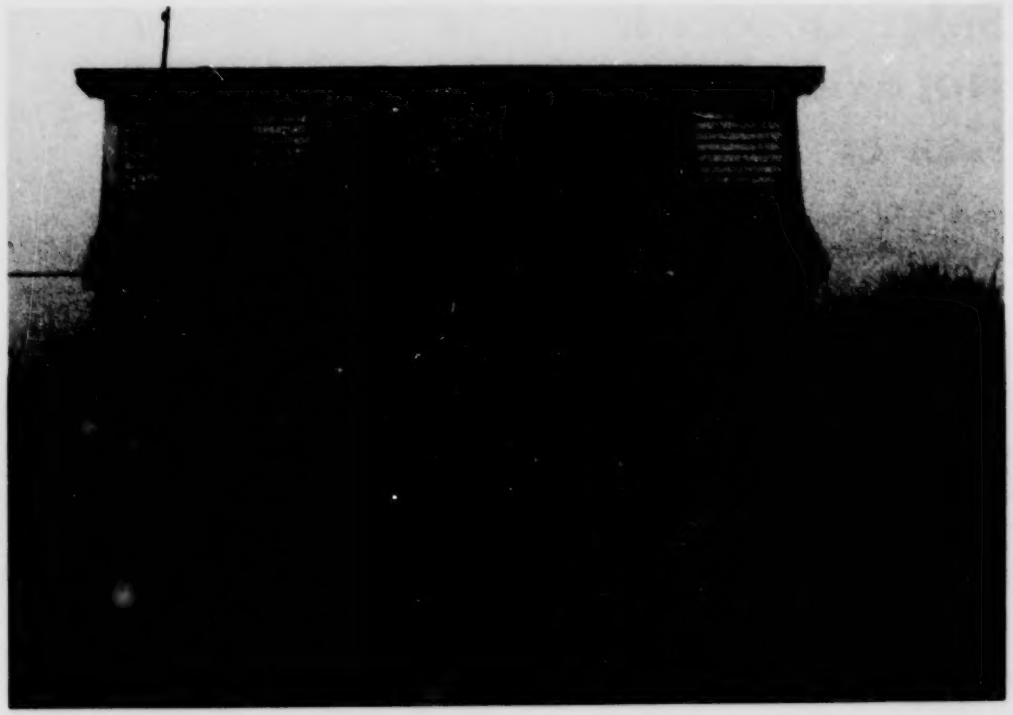
The solar system is expected to provide one-half the energy required to heat hot water for the five member Conlin family.

Economics:

The entire system has cost approximately $2500. The Sola Roll system enabled Mr. Conlin to build a very good system for less than the cost of a similar, commercial system.

Viewing:

Anyone wishing to view and discuss the project with Mr. Conlin, should phone in advance to make arrangements—**538-8195**.



Wall mounted solar collectors

Solar Domestic Hot Water Pre-Heater

Francis Xavier Dunn
North Sydney, Cape Breton County

Purpose:

The solar-heated hot water system will reduce the Dunn family's energy costs. The solar system will preheat the domestic hot water before it enters a conventional electric hot water heater. The electric heater will heat the water if required.

Description:

Mr. Dunn used a commercially produced "Amherst" packaged system with an anti-freeze solution in the collector panels. The two *"Amherst 100"* flat plate collectors have a total aperture area of 5.2 m^2 (55.7 sq. ft.). They are mounted on the south facing slope (52° from horizontal) of a garage roof.

The piping for the collectors runs through the interior of the garage and underground to the house. The two pipes are insulated with pliable foam pipe insulation and buried 1 m (3 ft.) below ground. They were covered with crusher dust and a strip of 50 mm (2 in.) rigid foam insulation before the trench was backfilled.

The pipes go to a 364 L (80 gal.) preheat tank in the basement of the house. This tank has a circulating pump, differential controller, pressure tank, and heat exchanger, mounted in the top of its sheet metal case.

The propylene glycol, non-toxic anti-freeze solution is circulated through the collector plates and heat exchanger by a single pump controlled by a differential thermostat. The pump comes on when the collector plate is sufficiently hotter (usually 2°C) than the water in the preheat tank. A separate pump circulates the potable water from the preheat tank through the heat exchanger to extract heat produced by the flat plate collector.

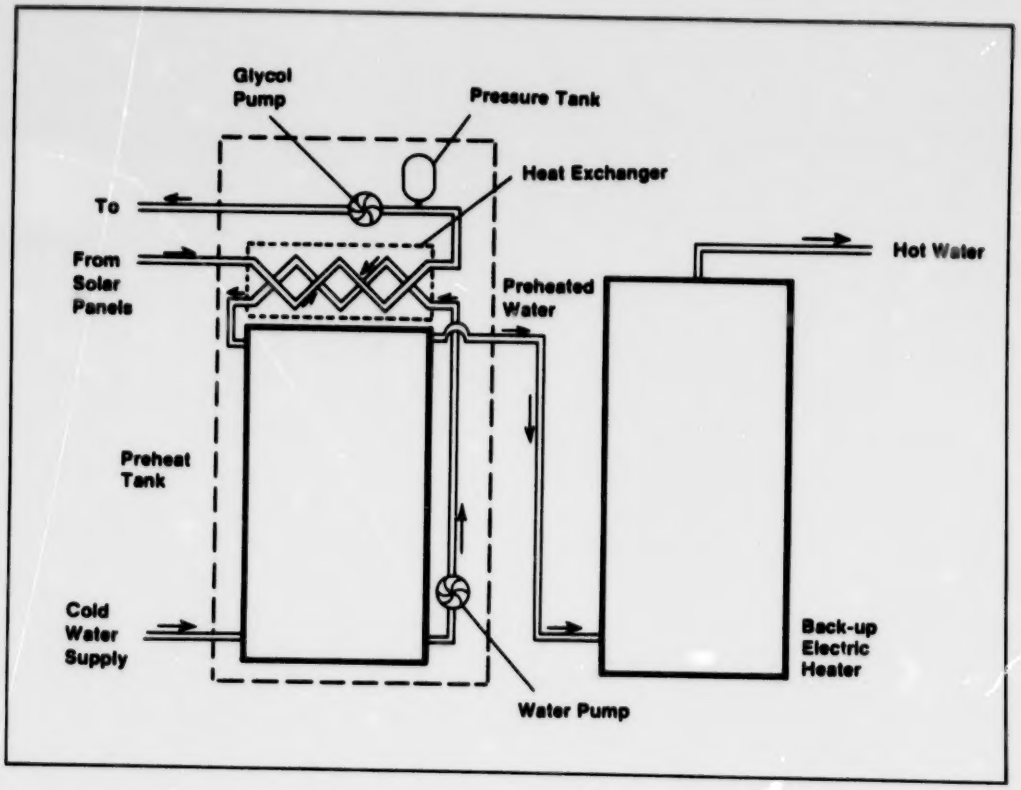
As hot water is drawn from the taps, warm water flows from the preheat tank into the cold water inlet of a 273 L (60 gal.) *"G.H. Woods, Energy Saver Water Heater"*. This heater has extra insulation and an easily adjustable external temperature control. If the water from the preheat tank requires further heating, the electric heater will automatically raise it to the desired temperature.

Performance:

Mr. Dunn's system should meet all the family's hot water needs during the late spring, summer and early fall months and reduce the electricity required to heat the water during the rest of the year.

Economics:

The material and installation for the complete solar system cost Mr. Dunn about $4,000. This cost includes a new electric hot water heater. The previous heater was an oil-fired unit; these units are not suitable in a system of this type because of their low operating efficiency when running for short periods of time.



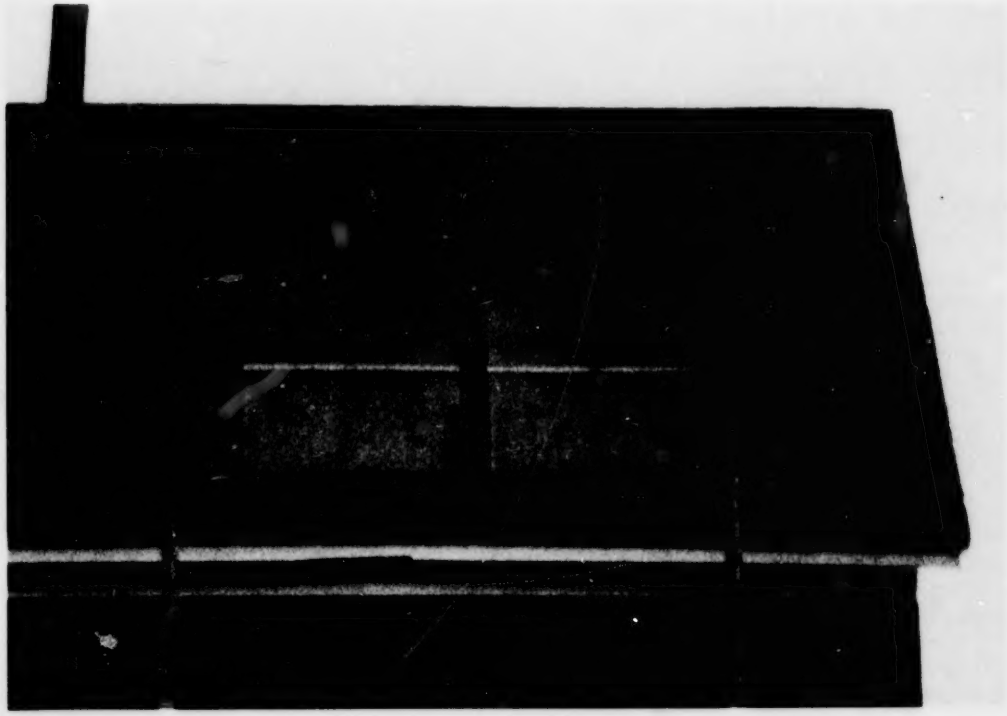
System Schematic

The completed system is very tidy looking and fully automatic. The only maintenance required will be replacement of the propylene glycol every two or three years to avoid corrosion.

Viewing:

Persons interested in viewing the system and discussing it with Mr. Dunn should telephone to make arrangements—**794-2803.**

Storage tank with internal pumps and controls



Roof mounted solar collectors

Solar Domestic Hot Water Heater

Harvey Eldridge
Port Saxon, Shelburne County

Purpose:

This passive solar system preheats domestic hot water. System liquid flow is by thermosyphon and a conventional propane water heater heats the water, if required.

Description:

The solar collector consists of one heat exchanger section from a walk-in freezer. It is made of 36 m (120 ft.) of 19 mm (3/4 in.) copper tube. The exchanger sits inside a 2.8 m x 1.25 m (9 ft. x 4 ft.) airtight woodbox with a single pane glass glazing.

The storage tank is a 100 L (22 gal.) range boiler, mounted under the floor joists inside the house. The tank is about 1 m (3 ft.) above the top of the collector and rests near the propane water heater.

Plumbing is shown in the accompanying sketch. When the hot water taps are closed and the sun is shining, heated water in the collector tubes rises and flows into the storage tank. Cold water from the bottom of the tank is displaced and flows into the bottom of the collector to be heated.

When the hot water taps are opened, hot water flows from the propane heater and is replaced by preheated water from the storage tank. The propane heater functions normally (although less frequently) and will automatically heat the water if required.

Preheated water enters the propane heater from the storage tank rather than from the collector because that pipe is shorter. Water follows the path of least resistance. The storage tank is less than 3.1 m (10 ft.) from the heater while the collector is 6.2 m (20 ft.) away and contains 37.2 m (120 ft.) of pipe. The water takes the short route from the storage tank rather than the long path through the collector.

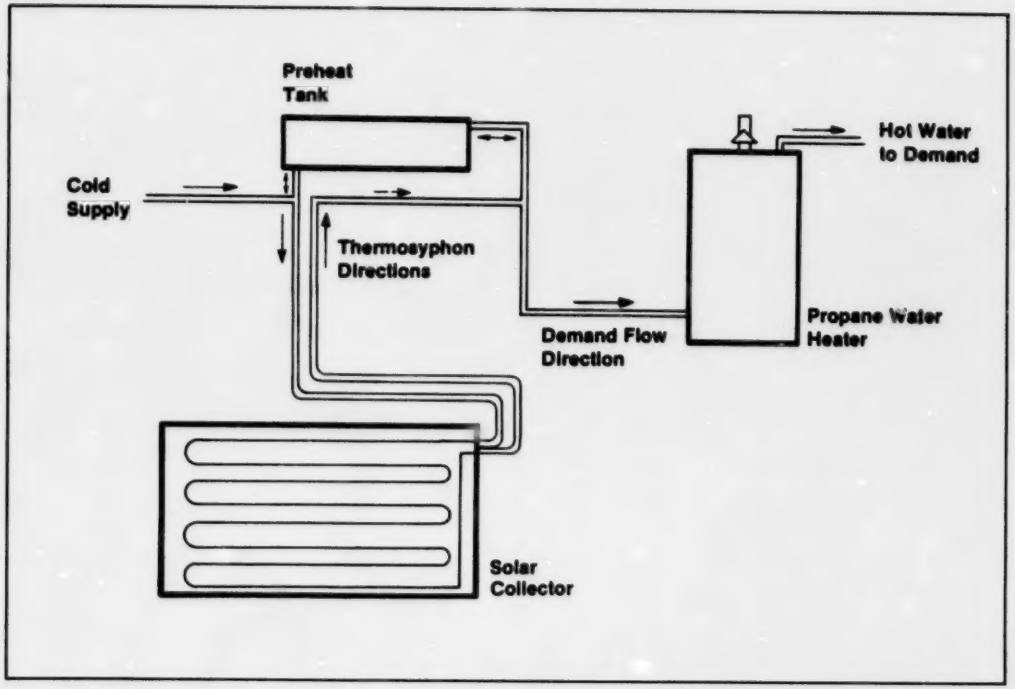
Performance:

The absence of thermometers or flow meters makes an energy analysis impossible. However, the fuel consumption of the propane water heater provides a good indication of the system's performance. Without the solar preheat system, the propane heater would use 45 kg (100 lb.) of propane in six weeks. With the system, 45 kg (100 lb.) of propane lasted 17 weeks during the cold and cloudy spring of 1981.

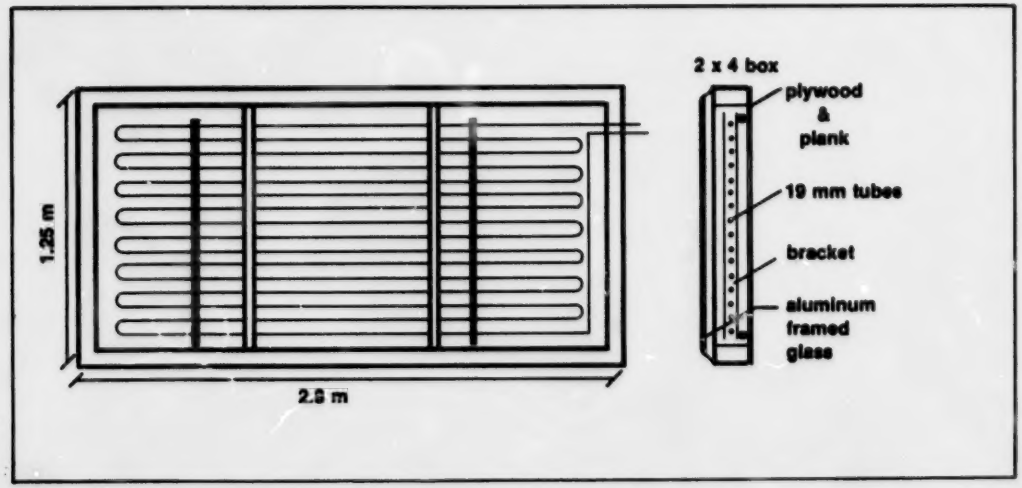
The lack of controls or circulating pumps makes this system interesting. The collector must be drained when the temperature drops below freezing, ruling out winter operation.

Economics:

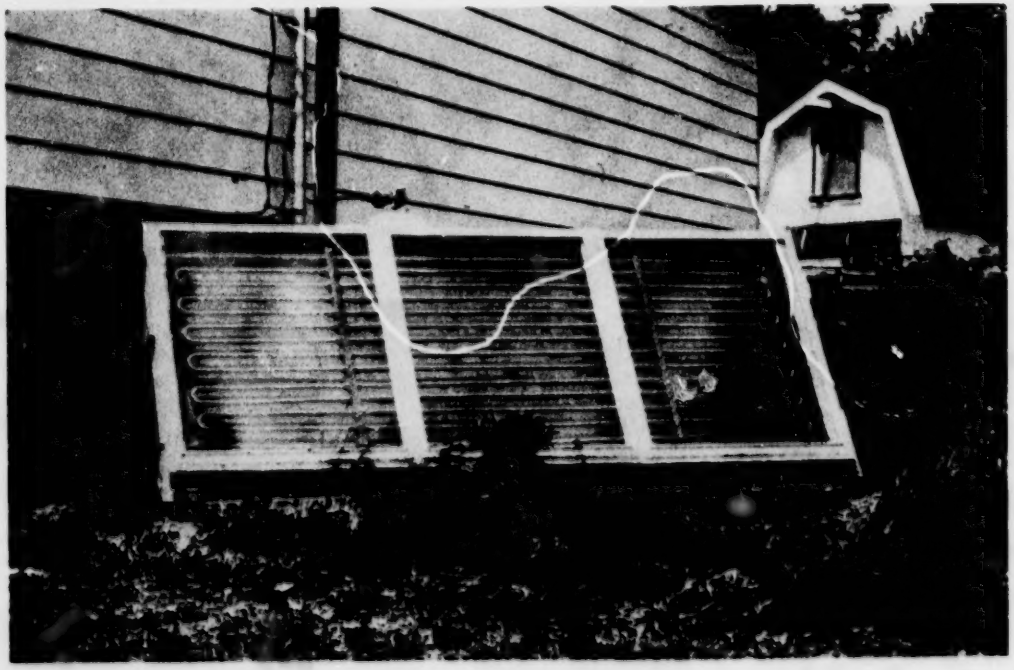
The system began operation April 5, 1981, and should be usable until November of each year. Mr. Eldridge is happy with his reduced propane consumption. The total cost for the system is about $200; at that price it is a very simple, cost-effective project.



System Schematic



Collector Design



Ground mounted solar collectors

Comments:

This system could be easily coupled with a wood or oil range water heater. In winter, when the solar system is drained, the range could provide hot water. In summer, when the range is not used, the solar system would heat the water.

Viewing:

Visitors are welcome anytime, provided they call in advance—**637-2078.**

Thermosyphon System With Freeze Protection

Dr. David F. Goble
Halifax, Halifax County

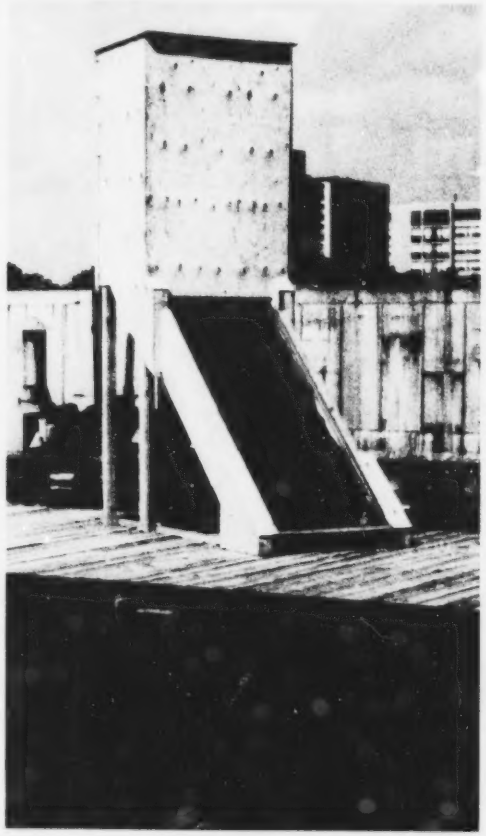
Purpose:

The project was undertaken to develop a modified thermosyphon system suitable for preheating domestic hot water (DHW) in areas where freezing temperatures are encountered. The system will be completely passive, in that there will not be any drain back provision or heat exchange and circulation system. Rather, the heat is transferred from the collector to the preheat storage tank through the action of a simply constructed "heat pipe".

Description:

Dr. Goble is developing a system which uses a "heat pipe" as the heat exchanger between an antifreeze filled, thermosyphon collector panel and the potable DHW. The system consists of a commercially available flat plate collector filled with an antifreeze solution, heat transfer from the collector to the domestic hot water system via "heat pipes", and a simple storage tank for the preheated water.

The key to the system is the "heat pipe". It is a completely passive means of transferring heat from the solar collector to the preheat storage tank. A "heat pipe" is made by taking a piece of pipe, capping one end, and placing a few drops of water in the other end. The water is made to boil and the second end of the pipe is capped. When tilted at a slight angle (30° works well), the pipe's upward conductivity is in excess of 10,000 times the conductivity in the "downward" direction. This effectively means that heat is only conducted upward.



Test Installation

A system constructed in this fashion has the advantage of being completely passive. It is simple because temperature sensors, pumps, or heat exchangers are not required. It would be suitable for use in Nova Scotia where winter temperatures often drop below freezing.

The test set up consists of a collector mounted on a wooden frame, tilted at 45° and oriented due south. An open, 23 L (5 gal.) heat exchanger tank is mounted above the collector panel with plumbing connecting the two. Above the heat exchanger tank sits a water filled 182 L (45 gal.) drum that simulates a preheat tank. The heat exchanger, tank and the preheat drum are connected by a 9.4 mm (3/8 in.) stainless steel "heat pipe". An enclosure surrounds the preheat drum. This simulates typical basement conditions and controls the drum's heat loss.

The antifreeze solution flows by thermosyphon through the collector panel and the heat exchanger tank. If the antifreeze is hotter than the preheat water, the "heat pipe" will conduct the heat upward to the drum. Due to the "heat pipe's" poor downward conductivity, very little heat will be lost from the preheat drum if the antifreeze is colder than the preheat water.

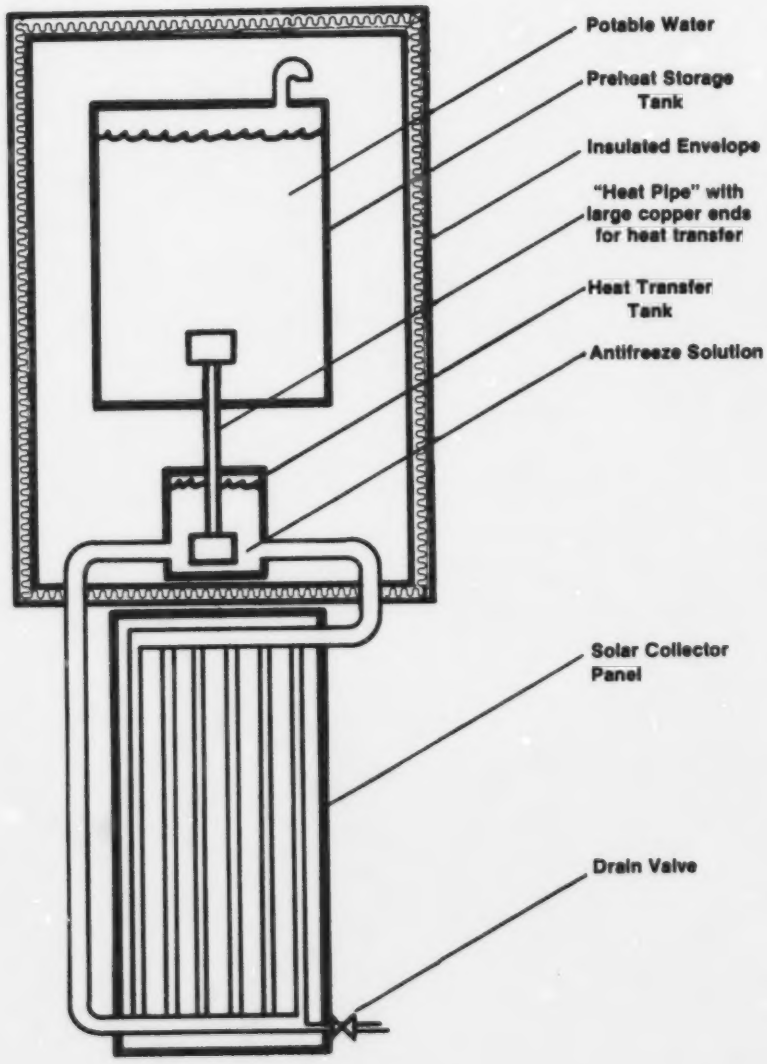
Performance:

Monitoring of the system began in July, 1981. Temperatures were recorded on a continuous basis at several locations in the system. A report will be prepared following collection of sufficient data.

Economics:

Should the system prove successful, it could greatly simplify and economize the installation of solar collectors that preheat domestic hot water. Dr. Goble's test set up will cost approximately $900. This cost is difficult to compare with that of an actual domestic system.

Eliminating the circulating pump and differential controls reduces the cost of a conventional system by about $300. The cost of the "heat pipes", however, will have to be added. Dr. Goble's system should enjoy greater reliability and lower maintenance costs than a conventional system and should require no external energy demand.



System Components

Comment:

Thermosyphon systems require the preheat storage tank to be mounted above the solar collector panels. This configuration is often difficult to place in an existing home but it can easily be planned for when designing a new home. A free-standing solar panel and preheat tank can be located away from the house and connected with insulated piping.

Viewing:

Halifax—The project was located on the roof of the Dunn Science Building, Dalhousie University. Those interested in discussing the project or viewing it should telephone to make an appointment—**424-3582**.

Solar Heated Domestic Water

James Hardy
North Lochaber, Antigonish County

Purpose:

The addition of solar heated hot water is another step towards energy self-sufficiency for Mr. Hardy's farm. Water has been heated by the wood range in the kitchen. The new system will provide hot water in summer when the wood range is not required for heating.

Description:

The solar collector panels are two *"Amherst 100"* units with a total surface area of 5.6 m^2 (60 sq. ft.). These collectors use a double glazing system of *Dupont Tedlar* and *Teflon FEP*, a combination of plastics that provides good solar transmittance and mechanical strength.

A 276 L (60 gal.) thermal storage tank was added to the original hot water system. (This was a 92 L (20 gal.) uninsulated storage tank and a heat exchanger in an airtight wood range.) The new storage tank is essentially an electric hot water heater with the heating elements replaced by copper fittings to allow circulation between the storage tank and the solar panel.

Mr. Hardy mounted his solar panels beside his house, slightly below the floor joists. The storage tank was placed on blocks in a closet beside the kitchen. This difference in elevation allows the water to circulate between the collector panels and the storage tank by thermosyphon. Thermosyphon also circulates water between the solar storage tank and the stove-heated storage tank.

Ground mounted solar collectors

The system has no heat exchangers or glycol solution. This makes it simple but has the disadvantage of possible damage from freezing.

Flanged couplings connect the collector panels to each other and the house's plumbing. This allows Mr. Hardy to disconnect his collector panels and store them for the winter.

Performance:

The system was completed in August 1981. It produced more than enough hot water for a family of three. Although there is no thermometer in the system to measure the actual water temperatures, they get quite high. After a sunny day, the water has to be cooled before one could wash with it.

The solar panels can be drained to prevent freezing, without interfering with the range hot water system. During the fall, when the outside air temperature drops near freezing, the solar panels are drained, and the wood range heats the home and hot water.

Economics:

Mr. Hardy did not replace an electric or oil-fired hot water system with solar heating, making energy cost comparisons impossible. It is difficult to determine the energy value of the wood used to heat the hot water because the system does not contain flow meters or thermometers. Mr. Hardy has added a system that provides hot water from an alternate energy source, and does not require wood range operation in summer.

The total system cost about $2,000. The components were all factory produced and easily installed. Mr. Hardy did most of the preparatory work himself. A plumber was required for only several hours.

Comment:

When Mr. Hardy retired to his farm in 1975, he faced a considerable cost to run electrical lines from the highway to his farm house. Rather than pay this cost, he installed a small hydroelectric generating system using an old sawmill dam, and small gasoline generator for back-up. The hydro system provides electricity year round except for one month in winter when the water supply usually freezes.

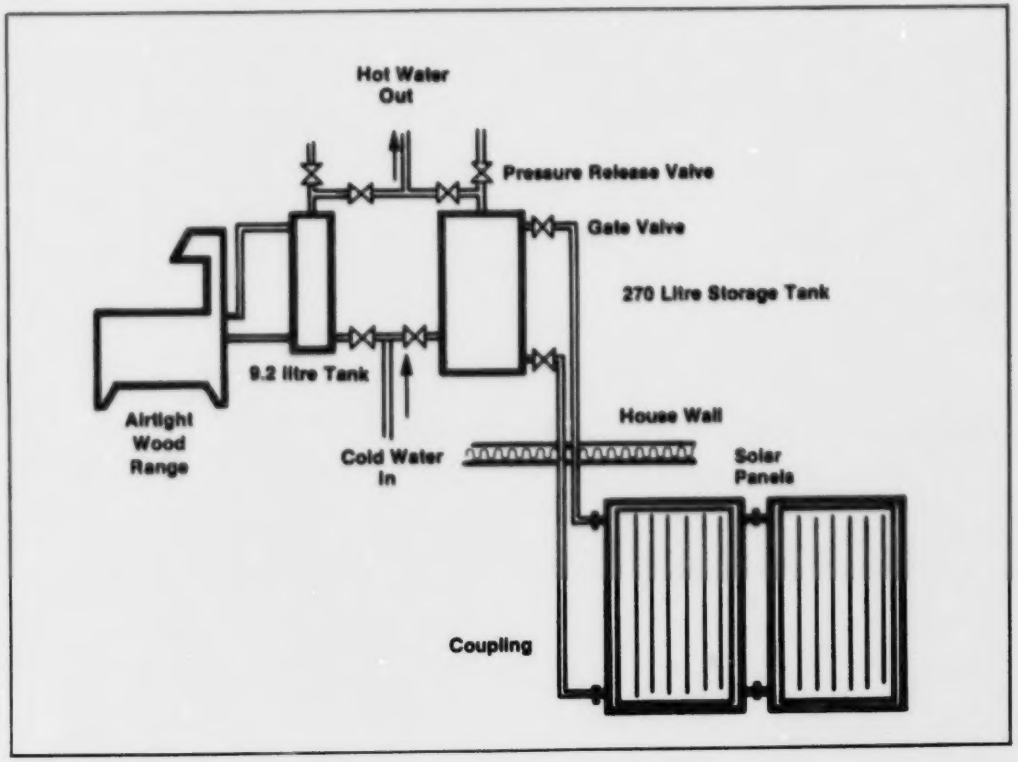
The farmhouse is heated with an airtight range and an airtight wood burner. All wood is cut from the Hardy's land. Since the house was insulated, the Hardy home has never been cold.

The domestic water is supplied by gravity feed from a nearby spring, so the water system operates without a pump.

A propane stove and fridge are used in the kitchen. These appliances, a car, a small farm tractor, and several small gasoline engines are the only articles dependent on "off the farm" energy sources.

Viewing:

Mr. Hardy is interested in showing his hydroelectric and solar installations to interested individuals. He asks that arrangements be made by telephone—**783-2329.** The solar system does not have freeze protection and is dismantled and stored in winter.



Hot Water System

Solar Heated Domestic Hot Water

David Harris and Louise McKenna
Gillis Lake Falls, Cape Breton County

Purpose:

David Harris and Louise McKenna have made a concerted effort to plan and build an energy efficient home. They chose an ideal site with hardwood stands, southern exposure, and a waterfall. Then they built a double wall, superinsulated house, and then added a solar greenhouse, and have further plans for adding hydroelectric generation. This current project is a solar domestic hot water system to provide all the energy for heating water in the summer and one-half of the energy required during winter.

Description:

The house is a double wall design with RSI-7 (R-40) insulation throughout. It has no north windows and the foundation is buried, except for the southwest corner, where an entrance and the greenhouse are attached. Ventilation air is drawn into the basement through 94 m (300 ft.) of 75 mm (3 in.) plastic tube, buried 1.9 m (6 ft.) underground in order to warm the incoming air to ground temperature.

An airtight wood burning range in the kitchen and an airtight wood stove in the living room provide heat. The kitchen range has a heat exchanger to heat domestic hot water. Porches over both entrances reduce heat loss due to infiltration.

A passive solar heated greenhouse will be added to the southern side of the house. The greenhouse foundation was poured at the same time as the house foundation. Glass makes up the front wall glazing and fibreglass panels cover one-half the roof. The other half of the roof forms a structure for mounting the solar collector panels for the hot water system.

In the future, water flow over the 6.8 m (22 ft.) waterfall will be harnessed to power a hydroelectric generator. There is sufficient water flow to provide enough electricity to meet the family's electrical needs year round.

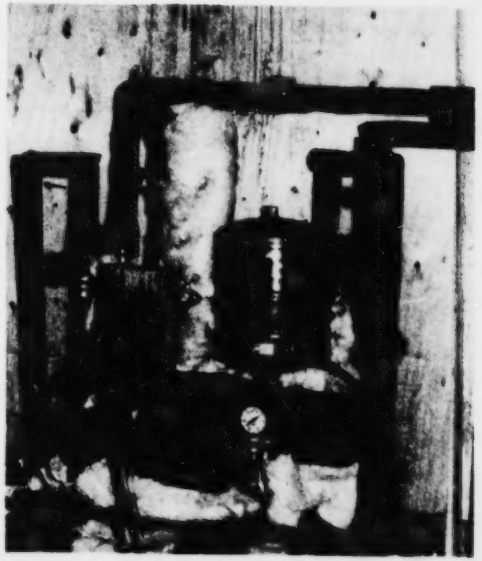
The current project is installation of a *"Kerr"* solar domestic hot water system. The packaged system has two collector panels, a control assembly, and a hot water storage tank. The system uses a propylene glycol solution to protect against damage from freezing.

The collector panels are mounted on the roof of the greenhouse. A wire runs from the aluminum collector frame to a ground rod as lightning protection.

The control assembly is mounted on the basement wall. A pump circulates the propylene glycol through the collector panels and a heat exchanger. An expansion tank is used to maintain pressure in the collector circuit. A change in the pressure within the collector circuit will indicate a leak in the system.

A second pump circulates the potable hot water between the storage tank and the heat exchanger. Both pumps are activated by a differential thermostat when the collector fluid is several degrees warmer than the water in the storage tank.

The storage tank is a 550 L (120 gal.) galvanized steel tank. It is insulated with 254 mm (10 in.) of fibreglass, insulation value RSI-6 (R-35). The solar storage tank can be used as a preheat tank in series with the wood range hot water tank in winter. In summer, the wood range's hot water tank can be bypassed and hot water will flow directly from the solar heated storage tank to the taps.



Controls, pump, and heat exchanger (insulated)

All the hot plumbing pipes are insulated with *"RCR"* foam pipe insulation.

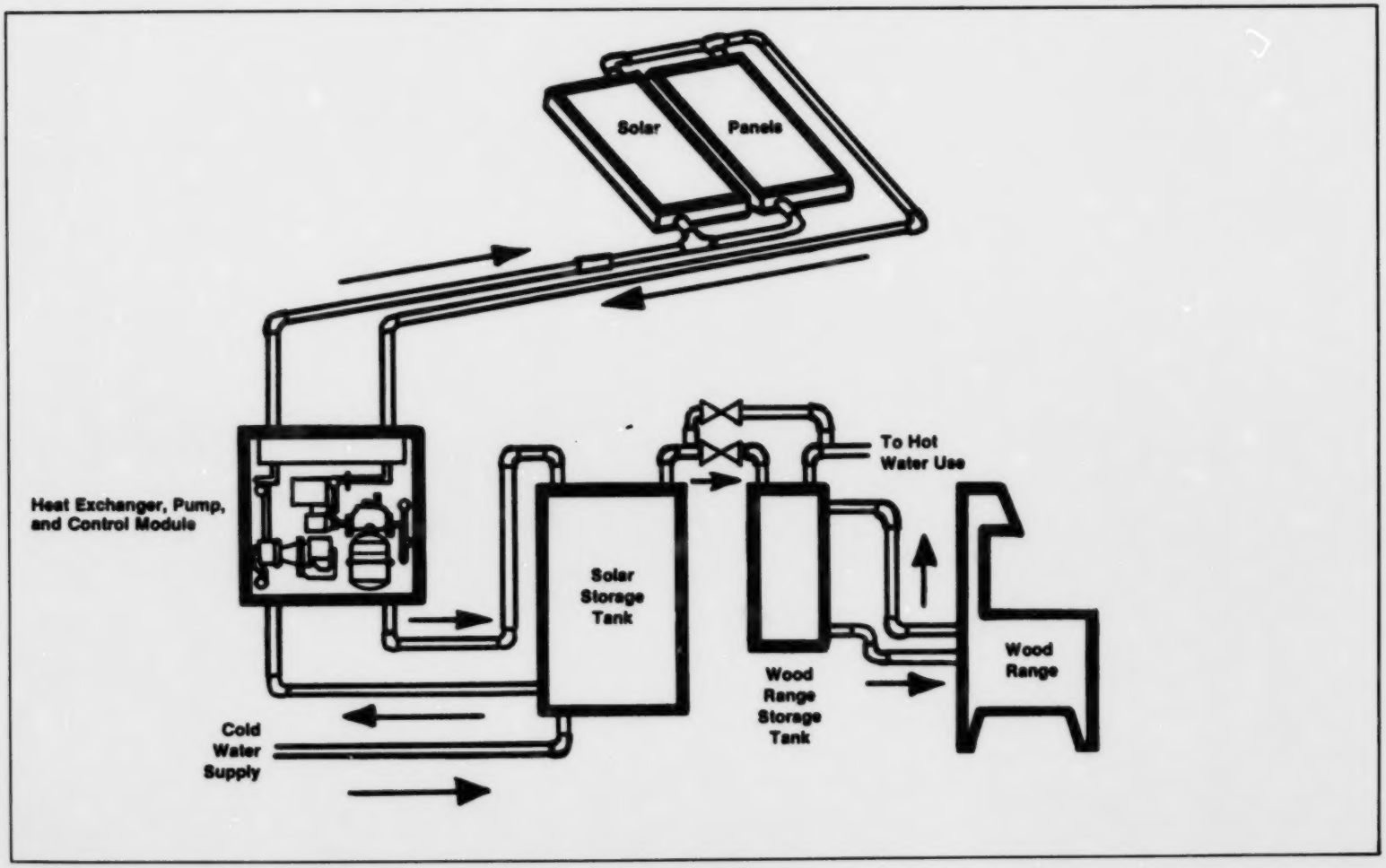
Performance:

The system was completed in 1981. It produced an adequate supply of 60°C (140°F) water. David and Louise both work. They use more hot water during the evening, after the solar system has had the whole day to heat the water.

On cloudy days, the system will collect heat. However, when it rains, the system is idle.

Economics:

David and Louise did not have an electric or oil-fired hot water heater prior to installation of this system so they have no previous fuel bills for comparison. The system will provide hot water in summer when the wood range is not in use. During the spring and fall, when the range is occasionally used for heating, the range will be able to bring the solar preheated water to an



Water Heating System

acceptable temperature. All the wood used for heating is obtained from their land.

The complete solar package cost $2,800. This particular package makes a very neat and tidy installation.

Viewing:

Visitors are welcome to discuss all aspects of the Harris-McKenna home. Please telephone in advance to make arrangements—**828-2663** after 6:00 p.m.

Self-Built Solar Domestic Hot Water System

Charles E. Henderson
Milford Station, Hants County

Purpose:
This project will provide solar heated or solar preheated hot water for domestic use.

Description:
The absorber plate in each of the three collectors is made from 13 mm (1/2 in.) copper tube bonded to a copper plate with copper pipe brackets and *"Thermon T-85"* cement.

The flat absorber plates are mounted inside collector boxes made from galvanized sheet steel. Each collector box is lined with a 63 mm (2 1/2 in.) layer of Pearlboard insulation. Extra fibreglass channel and wood hold the absorber plate in position.

Laminated beech arches hold the fibreglass glazing. The inner glazing is 0.5 mm (0.2 in.) *"Kalwall"* and the outer glazing is 1 mm (0.4 in.) *"Kalwall"*.

Each collector has a 0.9 m x 2.2 m (3 ft. x 7 ft.) opening for a total absorber plate area of 6.2 m^2 (63 sq. ft.).

The collectors are mounted on four 50 mm (2 in.) angle channels that run from the rear house wall to the lower edge of the porch roof.

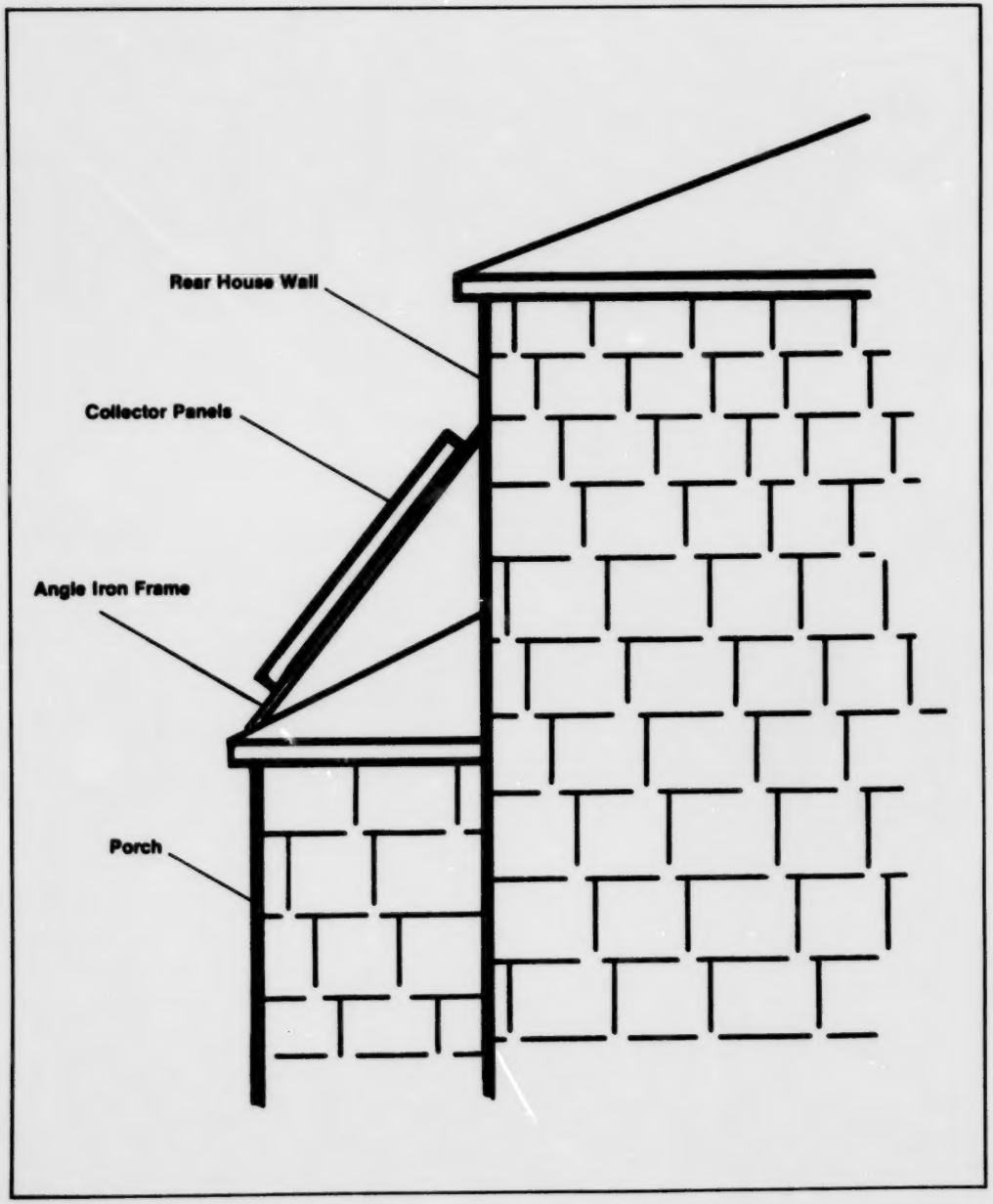
Plans to use an existing concrete cistern for storing preheated water were scrapped because the cistern's 3200 L (700 gal.) capacity was too large to be heated by 6.2 m^2 of collector. Two 300 L (60 gal.) electric hot water heaters were obtained from a scrap dealer. Both units had never been used but were cosmetically damaged. One tank is the solar heated storage or preheat tank while the second is plumbed in series with the first and operated as an electric hot water tank that is used only when required. Both tanks have been reinsulated to RSI-3.5 (R-20) with fibreglass batts and then covered with a heavy aluminum foil.

A damaged *"Kerr"* pump and control module was also obtained. One pump circulates the propylene glycol through the collector panels and heat exchanger and a separate pump circulates the potable water through the heat exchanger and the preheat tank. A differential thermostat controls the operation of both pumps. The module also has an expansion tank, air purge valve, and pressure gauge for the collector loop.

Performance:
Mr. Henderson calculated that the solar system would provide 60 per cent of the energy required annually to heat hot water within his home.

Economics:
The system cost about $2,600, a low figure given the quality of construction and materials. Similar commercially-produced systems cost about $4,500.

Mounting arrangement on rear of house



Collectors mounted on porch roof

Viewing:
Persons wishing to view the project should make arrangements with Mr. Henderson. His telephone numbers are **758-3508** (home) and **469-2972** (work).

Solar Domestic Hot Water System

William MacDonald
Sydney, Cape Breton County

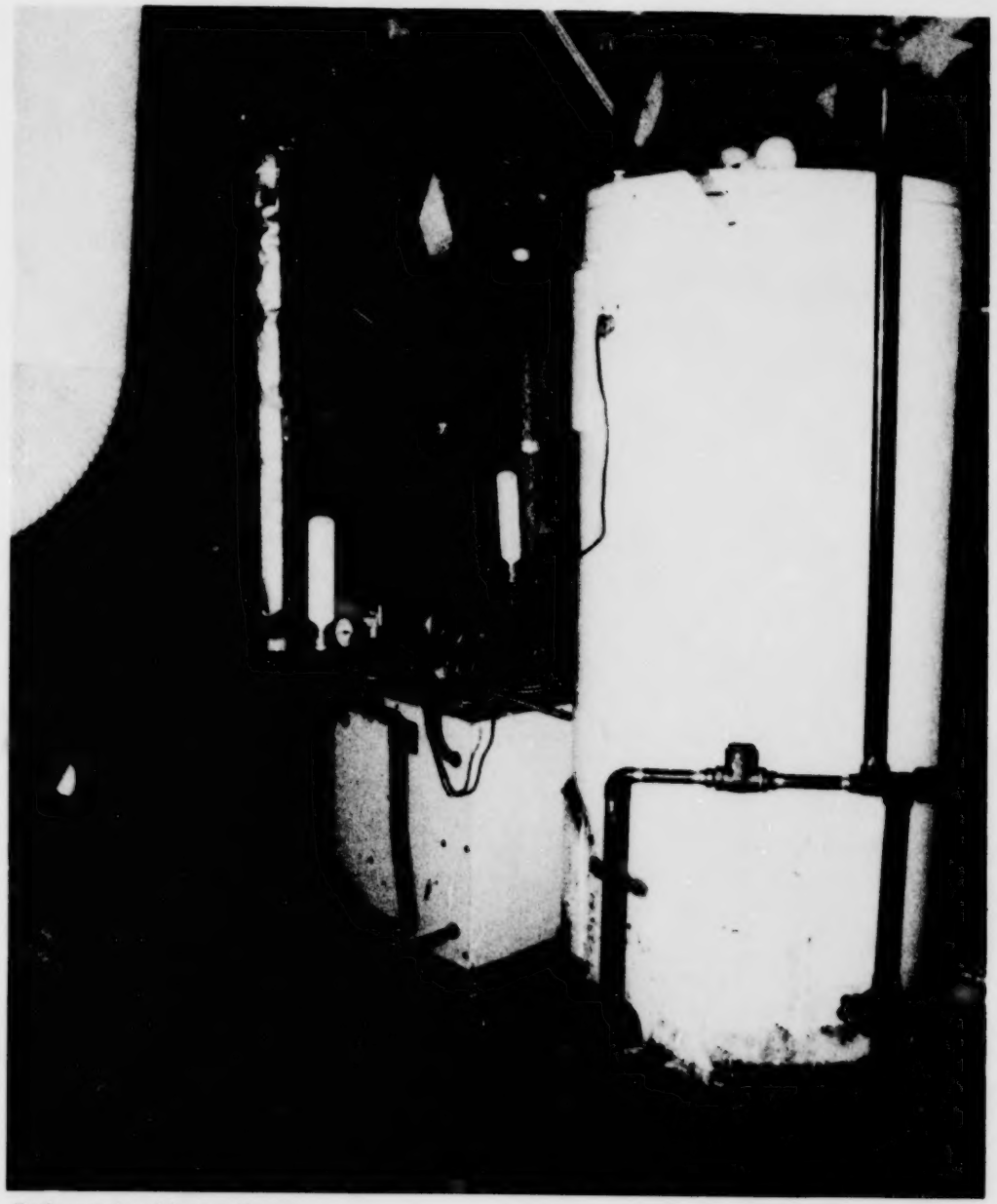
Purpose:
This project should supply 60 per cent of the MacDonald family's hot water. It is also a working demonstration of Mr. MacDonald's alternate energy business in Sydney—Home Energy Audit Limited.

Description:
Mr. MacDonald chose the packaged *"Nortec Thermal Diode System"*. The heart of this system is two *"Nortec TD 1000 Collectors"*.

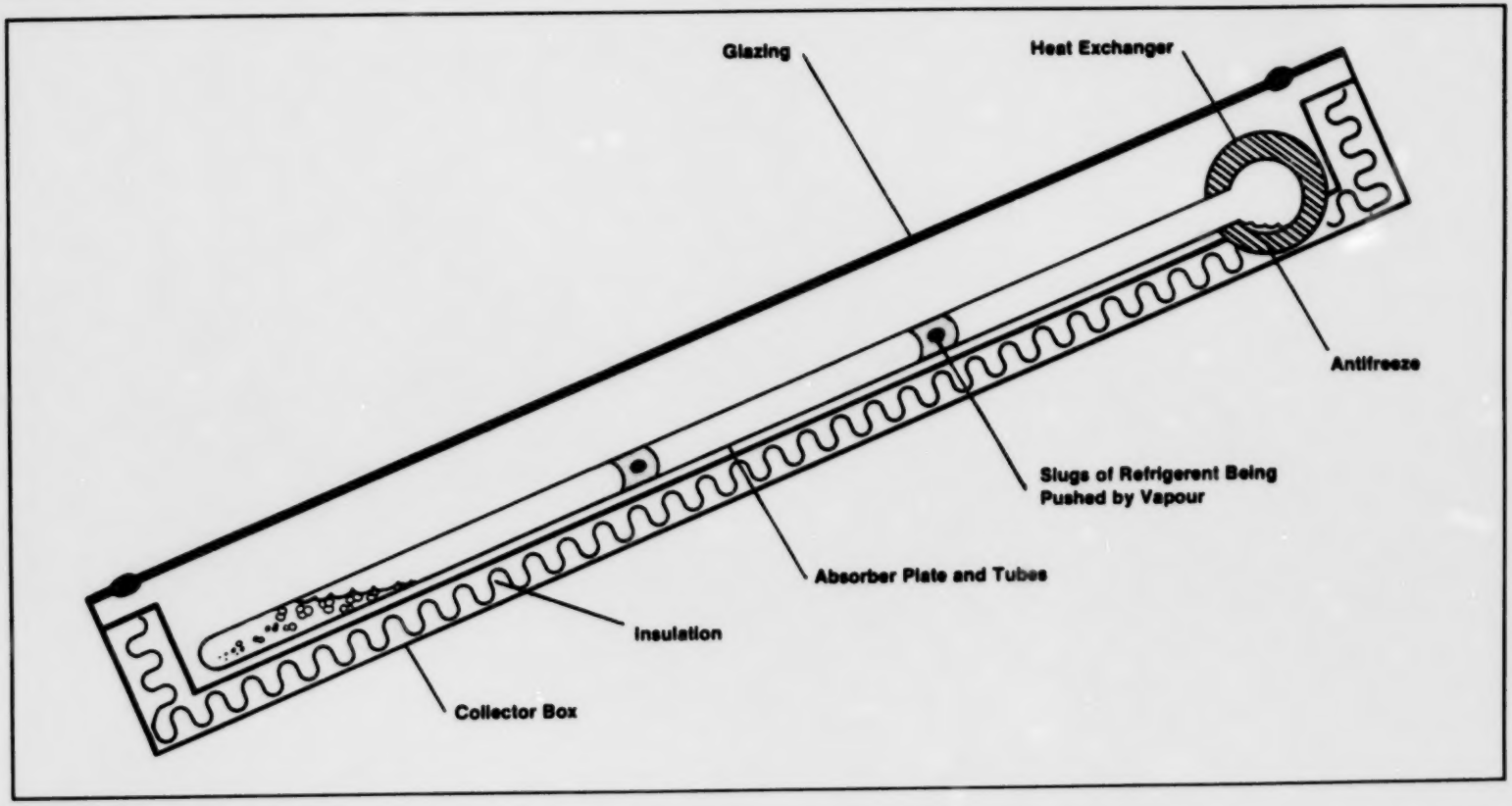
These collectors use a refrigerant. When the sun heats the collectors, the refrigerant is heated and turns to a vapour. The vapour rises in the inclined collector tubes, taking globules of hot refrigerant with it. In the heat exchanger at the top of the collector, the liquid and gaseous refrigerant give up their heat to a glycol solution. As the heat is released, the refrigerant becomes a liquid and returns by gravity to the bottom of the collector to repeat the process.

When the sun does not shine, the refrigerant remains as liquid in the bottom of the collector and the heat exchanger is surrounded by a low pressure vapour which has poor thermal conductivity. This virtually separates the heat exchanger from the solar collector, eliminating heat loss. This is the reason for the name *"Thermal Diode"*.

The glycol solution, which extracts heat from the refrigerant, is pumped through a second heat exchanger module in the basement, which transfers the heat to the domestic hot water preheat tank. From there, the preheated water



Preheat tank and heat exchanger



Refrigerant filled collector - Nortec

flows into an electric water heater where it is heated further, if required.

The system is not as complicated as it sounds since the collectors, glycol to domestic water heat exchanger, and the preheat tank all arrive as three separate units of a packaged system. A small volume of glycol fills two small heat exchangers and the pipes between the roof and the basement. The heat exchanger unit in the basement is simply a grey box with two pumps, four pipe connections, and an electrical plug. The preheat tank looks like a second hot water tank.

Mr. MacDonald used *"Unit-Strut"* metal channel for mounting the solar collectors on the roof. This is a versatile system, not unlike an adult *"Mechano"* set. It can be purchased through electrical suppliers who use it for electrical race-ways (or cable-trays). When mounting collectors on the roof, be sure to fasten them to the roof rafters or build extra support under the roof to distribute the load.

Performance:

The MacDonalds have not determined the energy the system produced. Since Mr. MacDonald is in the alternate energy business, he has many home projects, making it difficult to separate the benefits of each project.

Mr. MacDonald's calculations indicate that the solar system will supply 60 per cent of the hot water energy needs for his family of five, a saving of about $180 annually.

Economics:

The cost of the system was $3,600. This gives a simple pay-back of 20 years.

Viewing:

Mr. MacDonald welcomes anyone interested in viewing the project. Please telephone him at **539-5095** (work) to make arrangements.

Home-Built Solar Domestic Hot Water

Win Naugler
Port Williams, Kings County

Purpose:
This solar project is designed to make Mr. Naugler's innovative home more energy efficient. It will be monitored carefully to satisfy personal curiosity and as a practical demonstration for an alternate energy class at Horton District High School.

Description:
Mr. Naugler had built a 185 m^2 (2,000 sq. ft.) home with 56 m^2 (600 sq. ft.) of hot air solar collector built into the roof. Heated air is circulated through a 22 m^3 (800 cu. ft.) rock-filled, thermal storage bin. A conventional hot air ductwork system circulates the heated air through the house, and an airtight wood stove supplies back-up heating.

Collectors on south facing roof

With the assistance of the Small Scale Energy Demonstration Program, Mr. Naugler has added a solar domestic hot water system. The solar absorber plates are four *"Olin Roll Bond"* units. These are made from two thin sheets of brass welded together in selected areas and pressurized. This causes the non-welded areas to expand, forming channels for the heat exchange fluid. Mr. Naugler painted the plates flat black and mounted them inside the existing hot air collectors.

Copper tubing, insulated with rigid foam insulation, runs from the absorber plates to the basement. Mr. Naugler took a 50 mm (2 in.) sheet of *"Truefoam"* insulation and cut it into 100 mm (4 in.) strips with a radial arm saw. He positioned the saw slightly askew so that it cut a semi-circular groove along the center of insulation. Two of these pieces encase each pipe, for a RSI 1.9 (R-10) insulation level. Locally produced *"Truefoam"* insulation will not melt up to 82.2°C (180°F), a temperature hotter than a solar heating system should be allowed to attain.

Propylene glycol circulates through the collectors and heat exchangers, protecting the system from freezing. An *"Extrol"* expansion tank maintains a pressure of 138 kpa (20 psi) in the antifreeze loop while a *"Richdel R798A"* centrifugal pump takes care of circulation. A differential thermostat operates the pump whenever the collectors are warmer than the preheat tank. Two 1.2 m (4 ft.) *"Noranda d-a Heat Exchangers"* are used for transferring heat from the collector fluid to the potable water in the preheat tank.

Potable water in the 276 L (60 gal.) preheat tank circulates through the water side of the heat exchangers by thermosyphon. This preheat tank has an electric heating element near the top and operates as a normal electric water heater, raising the water to the desired temperature before it is used.

To monitor the system for personal satisfaction and classroom use, Mr. Naugler installed a flow meter in the water supply pipe, a watt-hour meter on the electric heater, and eight thermocouples with a digital display to measure various temperatures. He also plans to install a clock on the circulating pump, to determine running time, and pressure gauges on either side of the circulation pump to determine its flow rate.

Performance:

During sunny days in late January and early February 1982, the circulation pump ran continuously for five to eight hours a day. Water temperatures were high enough that the electric water heater did not operate at all on these days.

When the system has been operating for some time, Mr. Naugler intends to disconnect the electric heating element in the preheat tank and connect the old electric hot water tank in series, the normal procedure with preheat solar systems. He can then compare the performance of the two systems.

A problem developed because air returning to the air-type solar collectors from the rock storage bin cools the solar hot water panels. Mr. Naugler believes the solar hot water panels should be at the top of the hot air collectors, where the air temperature is higher.

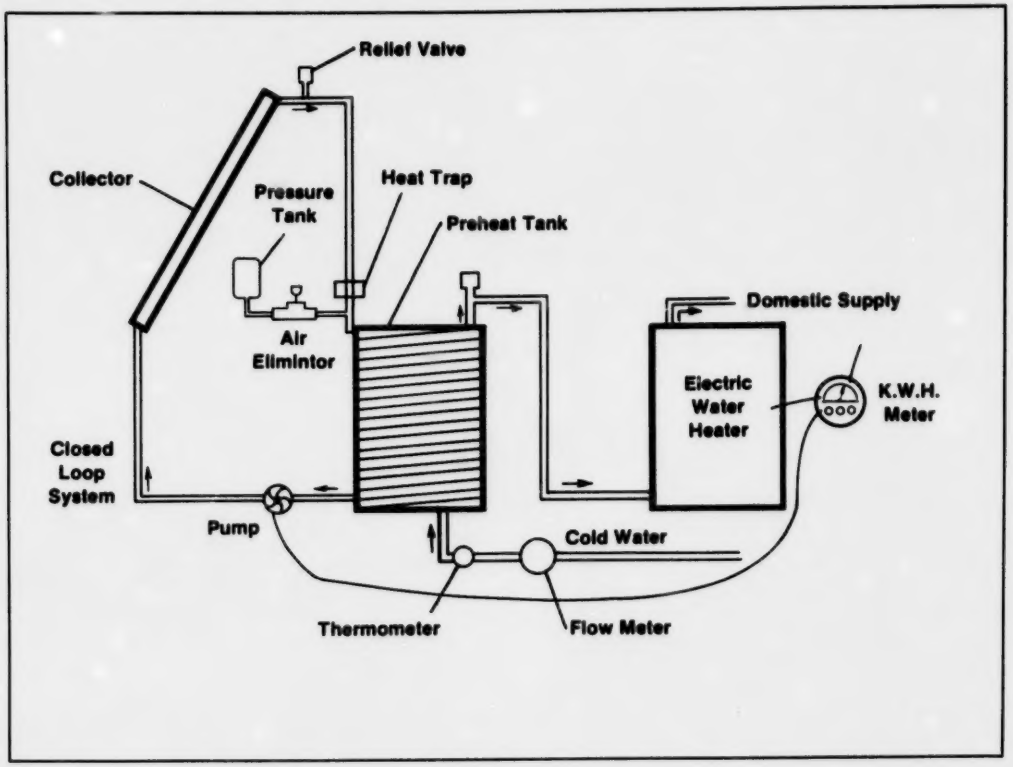
Mr. Naugler says the students of his Alternate Energy Class will be more interested in analyzing data from an operating system rather than in using a hypothetical model. The Nauglers are enthusiastic about solar heating and are making every effort to hasten its public acceptance.

Economics:

With some diligent catalogue searching and no sacrificing of quality, Mr. Naugler kept the system cost to $2,600, including the monitoring equipment. (The monitoring equipment would normally be left out.) Not only will this system decrease the Nauglers' bills, it will also expose students and the public to a working solar hot water system.

Viewing:

Mr. Naugler is very interested in showing his solar system to the public. Please telephone in advance to make arrangements—**542-3045** after 4:30 p.m.



Solar Water Heating System

Attached Solar Greenhouses

2

Attached solar greenhouses come in many shapes and sizes and serve many uses.

They can be added to almost any home with a south-facing wall with good exposure, making them available to just about everyone. Because of its universal application, a solar greenhouse may be the best alternate energy technology around.

These multi-purpose structures can do one or more of the following:
- supplement home heating
- provide a year round growing environment for plants
- create a sunspace for recreation and added living area

It is important when building a solar greenhouse to have a definite idea of how you want to use it. Intended use will heavily influence the greenhouse's design.

Costs range from $200 for the simplest structure to $7,000 or more for the most complex. Designs and materials used vary from concrete basements, cedar framing and double glazed windows to plain wood, earthen floors, and polyethylene vapour barrier walls.

An attached greenhouse's ability to supplement home heating also depends on how it is used. To heat effectively, the greenhouse must incorporate provision for circulating excess heat to the home and for reducing heat loss to the outside at night or on cloudy days.

There are several ways to do both. The majority of the greenhouses described in this book have two openings to permit air circulation between greenhouse and home: a lower opening allows cooler air into the greenhouse and a higher opening allows heated air from the greenhouse into the home. In several cases, a fan aids the flow of heated air to the home.

Heat produced in the greenhouse during the day can be trapped for later use by means of a storage medium. This medium can be water, as is the case in the project of Gary Eikenberry, rocks, as used by Everett MacLeod and Orval Meisner, a Trombe wall, as in Linda and Dennis Doyon's project, or a combination of the above. (A Trombe wall, invented by French architect Jacques Michel, is a concrete wall behind a glass window which captures and stores solar energy.)

These systems can incorporate vents, pipes, and fans to aid air circulation and heat distribution, as in the MacLeod and Doyon projects.

Heat loss from the home to the greenhouse can be prevented in two ways. The method used in Ron MacInnis' project is to seal the greenhouse from the house when temperatures drop below a desired level, and to reopen it when sufficient heat is available to supplement home heating.

If continuous use of the greenhouse is desired, removable insulation for the greenhouse glazing is required. The greenhouse owned by Carol Bowlby is a good example of this method.

Alternatively, heat may be supplied to the greenhouse, as required, to maintain temperatures suitable for growing plants year round or for other reasons, as is the case in the Gary Eikenberry, Ken Hill and Quentin Covey projects.

If properly designed and built, attached solar greenhouses seldom represent a net heat loss to a dwelling. Their contribution to home heating can be extensive, especially in the fall and spring seasons, and they can save several hundred dollars annually in heating costs for their owners. The attached solar greenhouses described here vary greatly in size and cost. Cost depends on the materials used, and desired use, which affects size.

Used materials are easily incorporated in a solar greenhouse and are plentiful, especially glazing materials such as old storm windows. Double glazing is desirable but triple glazing is not used for reasons of cost and reduced solar transmission. Insulating curtains, shutters, or other devices to prevent heat loss are a must for any successful project, unless heating bills are of no concern to the owner or the greenhouse is designed to be unheated and closed off from the house when temperatures dictate.

In summary, attached solar greenhouses can be a relatively low-cost addition to a home's living area without adding to heating costs. In many cases, a net heat gain is likely and possible with careful use and design.

An Urban Attached Sunroom

Sylvia and John Aldrich
Gorsebrook Ave., Halifax

Purpose:

The sunroom is a passive solar addition to the Aldrich home; it supplements the home's heating and also provides a suitable environment for growing plants. The Aldrichs' hired an architect to design a sunroom that blends aesthetically with the house, while maximizing solar performance.

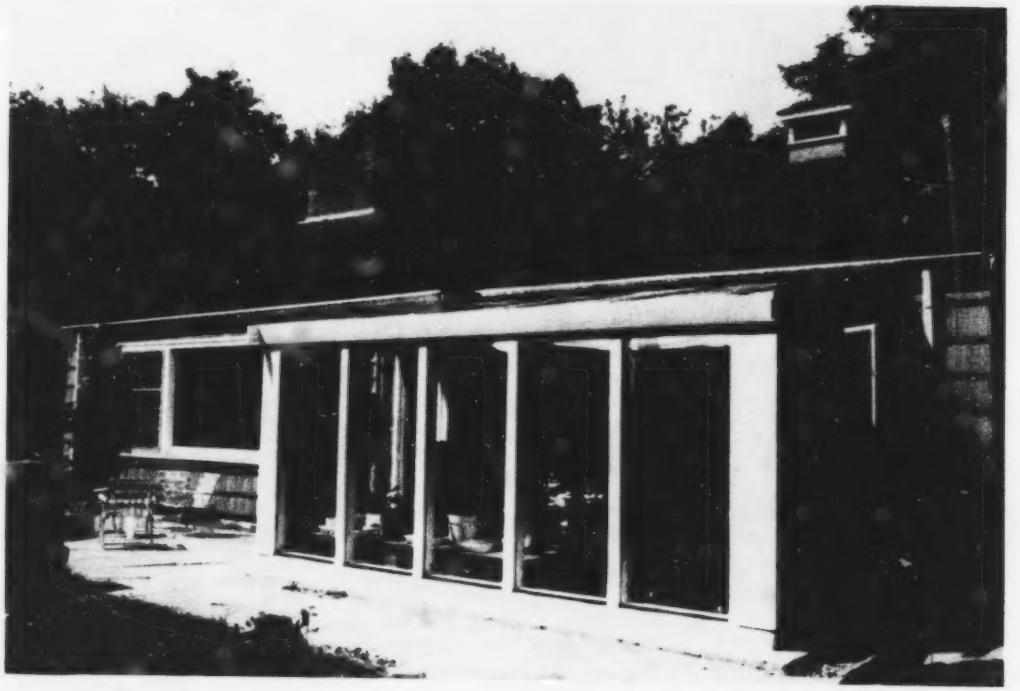
Description:

The sunroom is located in the backyard, on the south side of the Aldrich home. It shares two fixed windows and a door with the living room.

A portion of the patio was removed to make room for the addition. A 36 mm (8 in.) concrete slab floor was poured incorporating three air ducts. Rigid foam insulation was placed beneath the concrete, extending out from the edges. The patio was then repaired to the edge of the concrete.

The sunroom is designed and built around tempered glass, patio door inserts. These thermopane inserts are sold by a local manufacturer as "seconds" from his production line.

The room measures 3.1 m x 4.9 m (10 ft. x 16 ft.). The framing is made of heavy timbers, giving the structure a massive appearance while simplifying construction. The south wall has vertical glazing over its entire length. Most of the roof is also glazed. Unglazed wall sections are conventional 2 x 6 lumber construction, insulated with fibreglass batts, and covered with shingles to match the house.



Attractive Sunspace on South Side

The west wall has a sliding patio door opening to the patio, while the east wall has a thermopane window that can be opened. There are two vents, one located high on the east wall and the other located low on the west wall. Each vent is approximately 6 m^2 (2 sq. ft.), and is operated by a wax-filled mechanical device similar to a "SolarVent". These devices open the vents when the interior temperature rises and close the vent when the temperature falls. The particular brand Mr. Aldrich bought comes from Britain, and is not available in Canada.

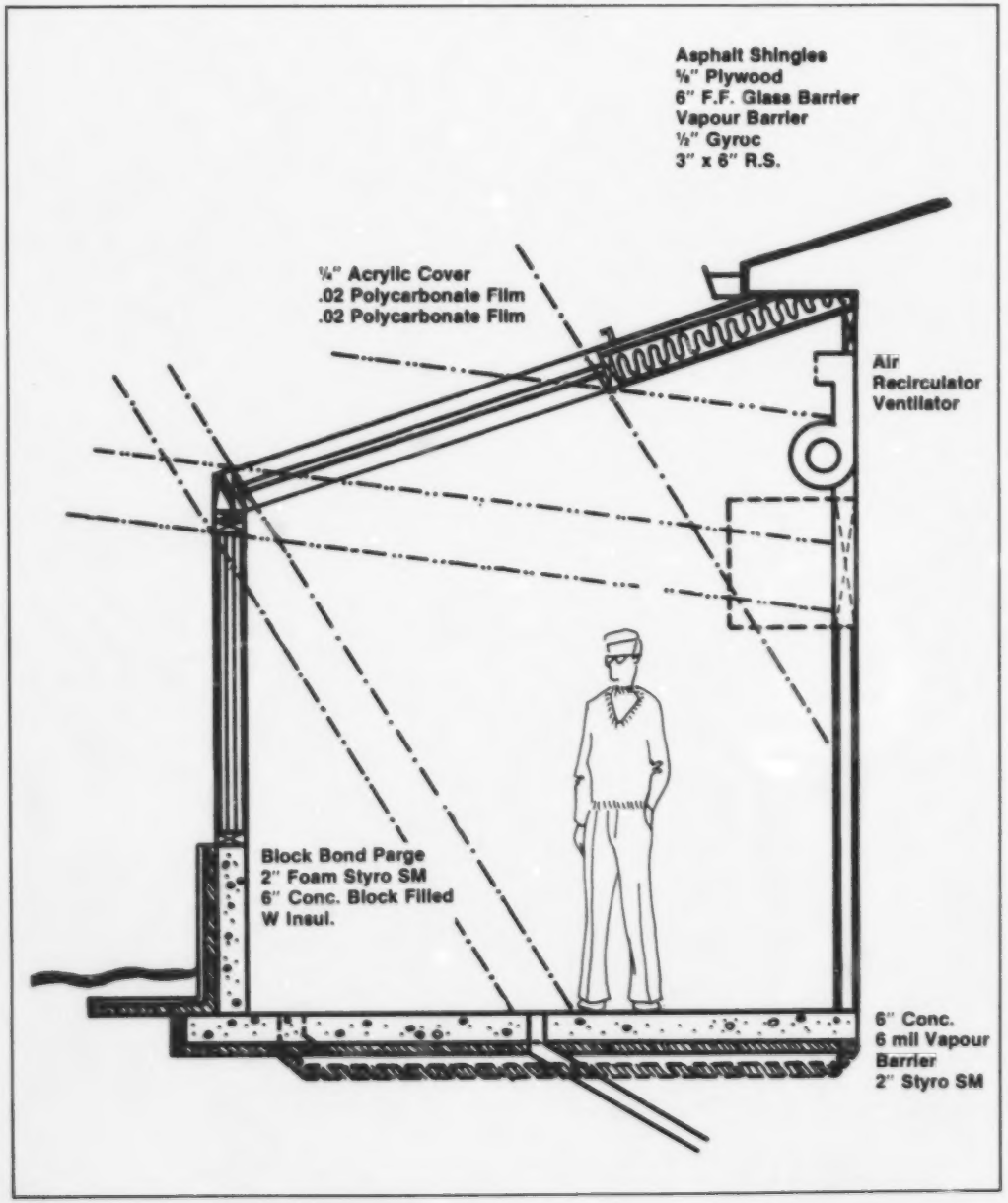
A fan forces hot air from the peak of the sunroom through the metal ducts imbedded in the concrete floor. Heat is stored in the concrete when air temperatures are higher than the temperature of the concrete, and heat is extracted when the concrete is warmer than the air.

Air exchange between the house and the sunroom is restricted to airflow through the living room door.

Movable window insulation will be installed behind the glazing to reduce summer heat gain and reduce night heat loss. The Aldrichs are presently looking for a suitable, inexpensive system.

Performance:

The sunroom's ability to supplement the home's heating is limited by the relatively poor circulation through the single door. The architect's calculations show that the sunroom



Aldrich Solar Greenhouse

has the potential to supply 1/4 of the annual home heating needs.

Aesthetically, the sunroom is a large success, blending very nicely into the twenty-year-old house. However, without window insulation, the sunroom becomes uncomfortably hot in the summer. Natural ventilation through the vents, window, and door is insufficient to keep the room comfortable. Consequently, some of the sun pouring in through the glazed portion of the roof needs to be blocked.

Comments:

For a cost of over $4,000, the Aldrichs have a lovely sunroom which is not only energy self-sufficient, but which will produce an energy surplus. Future work on the insulating curtains will improve the performance further.

Viewing:

Persons interested in viewing the project should call in advance to make arrangements—**423-5497.**

Inner City Attached Greenhouse

Carol Bowlby
Halifax, Halifax County

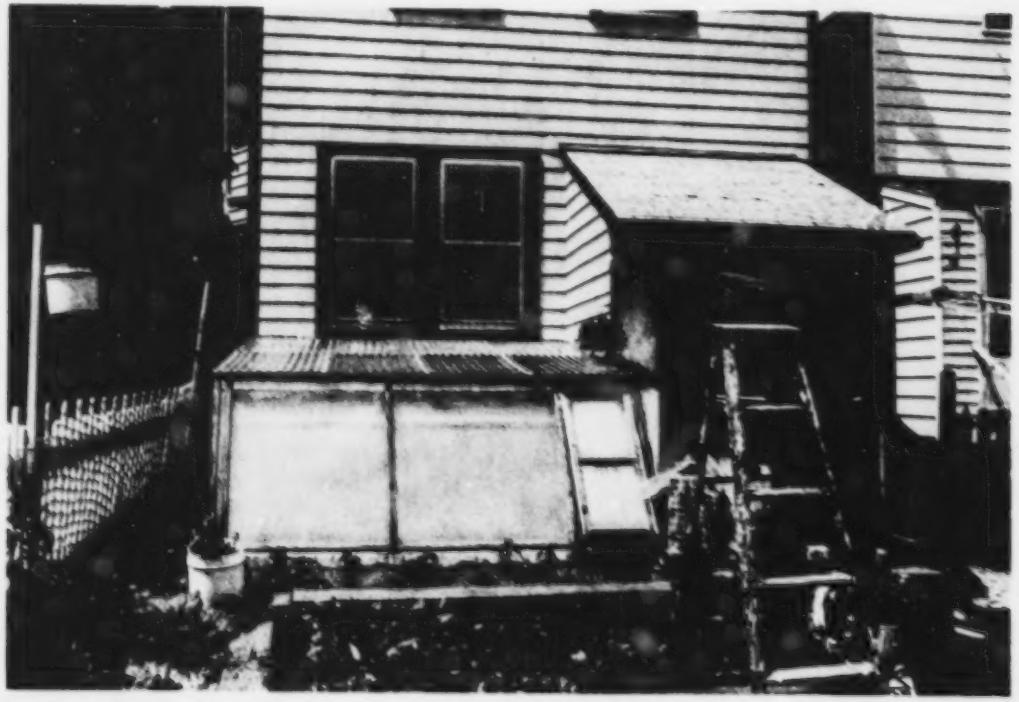
Purpose:

Carol Bowlby is an avid gardener who teaches an intensive organic gardening course in Halifax. She has built an attached greenhouse with the primary intention of demonstrating the potential for food production within an urban environment, without relying on non-renewable energy sources. She is also very interested in the therapeutic potential of year-round gardening for the infirmed. The results of the greenhouse project will be made available to the public through her courses and individual discussion.

Description:

The 2.3 m x 3.1 m (7 1/2 ft. x 10 ft.) structure is tucked behind the Bowlby house, beside the porch, along the south-facing, rear wall. Growing beds are at ground level, with a deep walkway down the middle. This low profile keeps the roof of the structure below the bottom of the kitchen windows, simplifying construction and not obstructing the view.

The concrete foundation was excavated and poured by the Bowlby family. This work had to be done by hand since the backyard is inaccessible to heavy equipment. A 30 cm (1 ft.) deep layer of rock was placed in the bottom of the foundation, to act as a heat sink. A wire reinforced plastic tube was placed upright in the rock, under the north growing bed to help distribute heat. Fifty millimetre (2 in.) rigid insulation was used on the outside of the foundation wall and beneath the rock storage to bring the thermal mass within the building envelope.



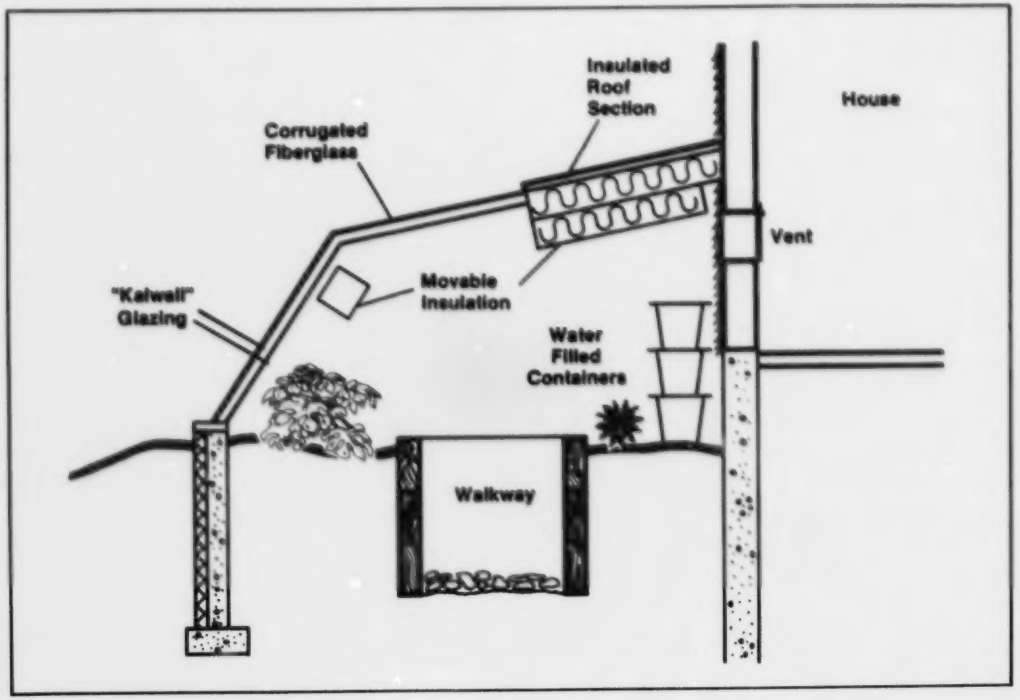
Exterior View of Greenhouse

The wood framed, greenhouse structure was built by a carpenter. The south wall has a 70° slope using wolmanized, 50 mm x 100 mm (2 by 4 in.) lumber. The roof is made from 50 mm x 150 mm (2 x 6 in.) wolmanized lumber. One-half of the roof is covered with plywood and asphalt roofing. The other half is covered with corrugated fibreglass panels of sufficient structural strength to carry snow loads. The east, south, and west walls are all covered with *"Kalwall"* fibreglass inside and out. A single layer of *"Kalwall"* is used under the corrugated fibreglass. This double glazed system reduces winter heat loss.

All non-glazed areas are insulated with fibreglass insulation. Wooden shutters filled with insulation slide from under the unglazed roof portion to cover the glazed portion. On the sloped walls, insulated roller blinds pull down to cover the glazing. This system effectively reduces the night-time heat loss due to infrared radiation and thermal conduction. During the summer, when the insulated blinds are not required, they can be removed and stored elsewhere, reducing the interior shadows.

Thirty, 18 L (4 gal.) plastic pails filled with water are stacked along the greenhouse's north wall for additional thermal storage. Initially, the pails have been left white. They may be painted a dark colour in future to determine the best balance between thermal and botanical performance.

Warm air from the greenhouse can rise through a vent into the kitchen to supplement the home heating during the winter months. Cool air



Cross-section of greenhouse

returns into the greenhouse through a basement window or the access door in the porch.

The greenhouse has two vents that open automatically to cool the interior. Refrigerant filled devices, *"Solarvents"*, open the vents at the preset temperature. When the interior cools, the vents close.

Performance and Economics:

Mrs. Bowlby's calculations show the greenhouse will reduce home heating requirements by 5% while producing $700 worth of vegetables in one year.

The ability of an attached greenhouse to supplement home heating is highly dependent on the way the structure is used. Heat may be stored in the structure to keep it warm (i.e., support plants) or it may be ducted into the house to supplement home heating. Mrs. Bowlby has chosen to sustain the plants. Other people use their greenhouses only to extend the growing season, rather than for year-round crops. A larger amount of supplementary heat can be supplied by the greenhouse if hot air is ducted to the house rather than used to heat thermal mass within the greenhouse.

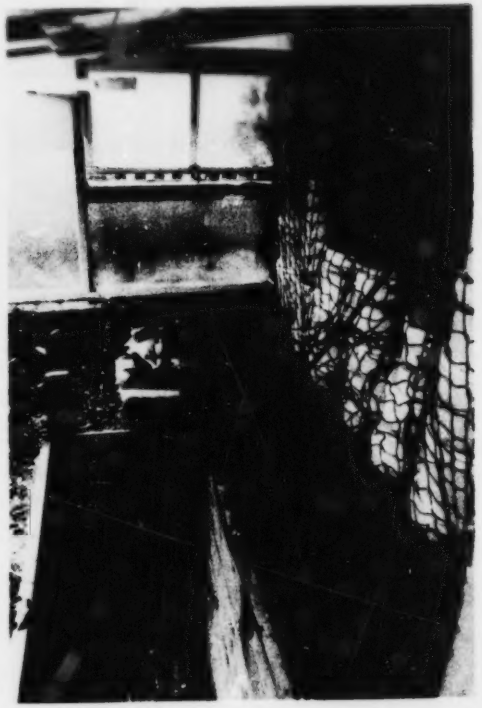
The attached greenhouse cost about $3500. High quality, but not extravagant materials, were used throughout. The high cost of hired labour was offset to some extent by personal labour on the foundation and insulating blinds.

Comments:

Mrs. Bowlby's project met with numerous delays. The longest delay was for a building permit. The other major delay was for the carpenter to find the time for such a small project. We recommend that one check all building permit requirements well in advance of actual construction and obtain, in writing, a firm construction date, as well as price, from all contractors.

Viewing:

Mrs. Bowlby is very interested in showing her greenhouse to the public. However, as of this writing, she will be away for two years while her husband is on a sabbatical leave. Her tenants will show individuals through the greenhouse, provided arrangements are made in advance, telephone—**423-2064.**



Interior of Greenhouse with Water Storage at right

Passive Solar Sunroom Collector

Wayne J.J. Buckley
St. Bernard, Digby County

Purpose:

The Buckleys wanted to carry out a low technology, passive solar retrofit of their eight year-old home. They chose to build a sunroom since it employed conventional construction techniques and materials. Heat can be readily transferred to the house or stored passively in the building's mass.

Description:

The sunroom was built on the rear, south side of the Buckley home. It encloses a large brick chimney which acts as thermal mass.

The room measures 5.7 m x 3.0 m (18 ft., 8 in. x 10 ft.). It is built on a 1.2 m (4 ft.) deep concrete foundation that is insulated on the outside with rigid foam insulation. The interior floor of the sunroom is .2 m (8 in.) of concrete, painted dark brown to aid thermal absorption.

The framing for the structure is all 50 mm x 150 mm (2 x 6 in.) spruce lumber. Thermopane glass was used throughout for all the walls and the roof. Special glass sections were used for the odd-shaped areas near the roof peak and base of the front wall. An aluminum door installed in the west wall allows access to the rear, and provides additional ventilation.

A vertical duct runs from the sunroom floor to a grille near the peak of the roof. A lid, operated by a *"SolarVent"*, uncovers the duct when sunroom interior temperatures are high enough. This grille and duct are connected to the cold air return of the furnace.

Rear View of Sunroom

Three operating modes are possible. First, if the air in the sunroom is hot, a thermostat turns on the furnace blower, and air from the sunroom circulates through the house (scatter rugs placed over the cold air returns enhance the draught from the sunroom). Second, if the furnace is required, warm air from the sunroom supplements heat provided by the wood and oil furnaces. Third, when the sunroom is cool and the furnace comes on, the SolarVent closes the lid so the furnace will function normally.

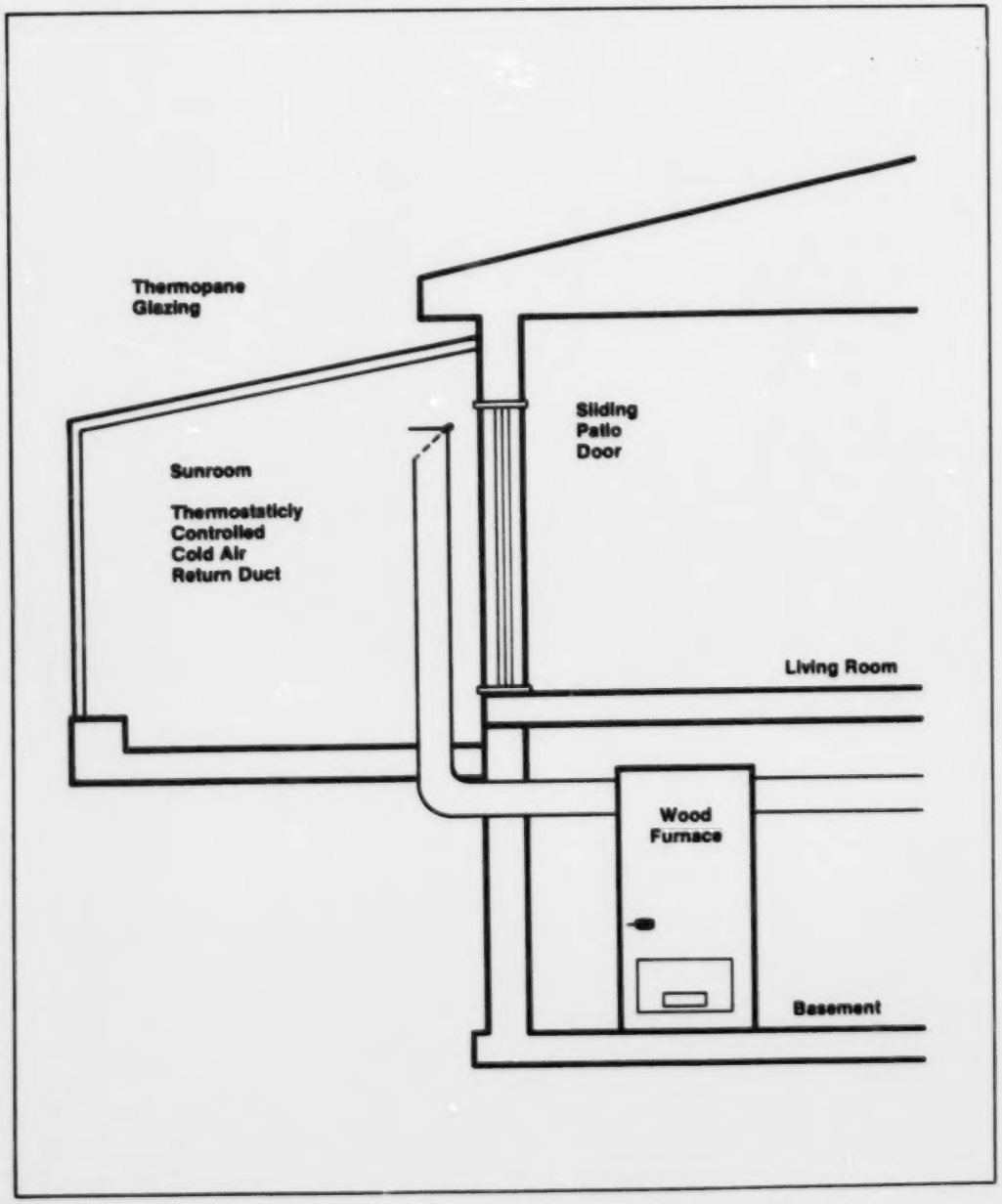
Cool air can return to the sunroom from the living room through a sliding patio door. Two vents and an outside aluminum door provide summer cooling.

Roller blinds, installed beneath the glass of the roof, block a portion of the summer sun, reducing the interior temperatures. Insulated curtains will be installed at a later date to reduce night-time heat losses. At present, the structure is isolated at night and allowed to cool. The thermal mass of the concrete floor and the brick chimney moderate interior temperatures and provide a measure of thermal storage.

Economics & Performance:

The total cost for the structure has been just over $3600. This equates to a cost of $210/m^2 ($19.50/sq. ft.) of floor space which is lower than conventional construction costs for a similar living space. This living space differs from conventional rooms in that it produces a surplus of energy.

Since the structure is new, the Buckleys do not



Cross-section of Sunroom

know how much surplus energy it will produce. Performance will be determined over the coming winter.

Viewing:

The Buckleys are eager to show the project to the public. Please phone in advance to make arrangements—**837-5295.**

Attached Solar Greenhouse

Dennis & Linda Doyon
Smelt Brook, Victoria County

Purpose:

The Doyons are incorporating a solar heated greenhouse in an energy efficient addition to their home. Excess heat from the greenhouse will be ducted to the addition. The greenhouse will be used for maturing vegetables such as tomatoes and peppers after the outdoor growing season ends.

Description:

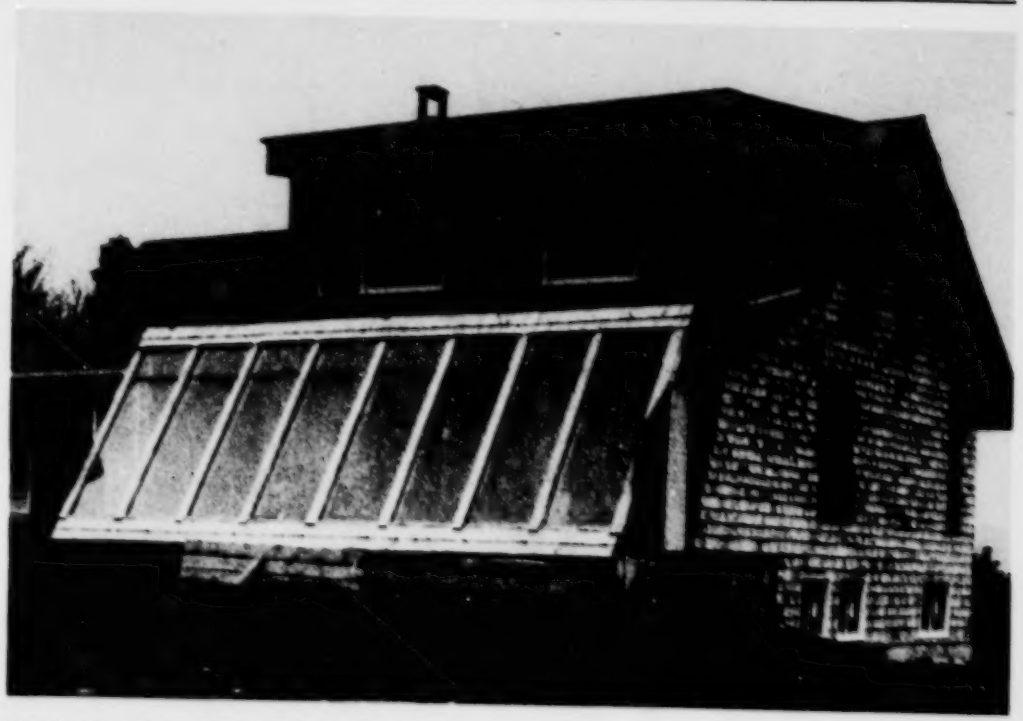
The 3.1 m x 6.9 m (10 ft. x 22 ft.) greenhouse is on the south side of the addition. The two structures share a full concrete foundation. A concrete dividing wall separates the two and doubles as a Trombe wall.

The Doyons plan to eventually use the space under the greenhouse for thermal storage. Thermal storage now consists of the Trombe wall, a masonary floor, and assorted water containers. The Doyons are in the pottery business and are considering using their clay stockpile as thermal mass.

The greenhouse and the addition have 50 mm x 150 mm (2 in. x 6 in.) wood frame walls. The roof of the addition is a double, 50 mm x 100 mm (2 x 4 in.) box truss. This allows for RSI-3.5 (R-20) wall insulation and RSI-7.0 (R-40) roof insulation.

Mr. Doyon is experienced at framing windows. He installed *"Twindow"* panels, a commercially produced, double glazed panel, into a home-built pine frame that allows ample room for thermal expansion.

Each 2.6 m x 0.9 m (8.5 ft. x 2.75 ft.) glass panel was set into rabbetted edges of the greenhouse rafters. An automotive sealing compound seals the glass to the frame.



Exterior view of greenhouse under construction

The greenhouse has one insulated door on the outside and another leading to the living area.

Warm air from the greenhouse is ducted to the loft of the addition. A large, slow moving fan pushes the warm air down into the living area. Cool air moves from the living space to the greenhouse through vents in the Trombe wall.

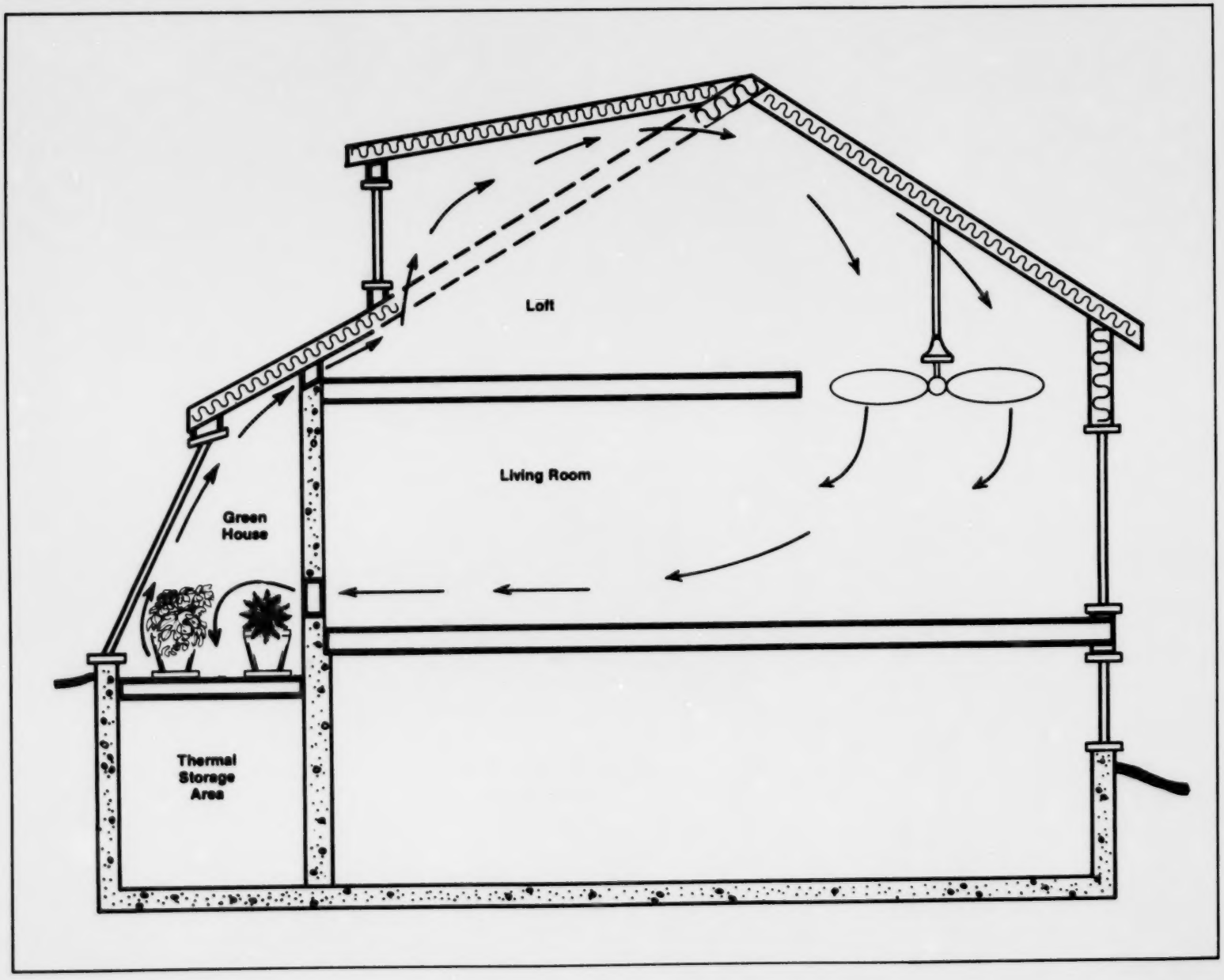
Evaluation:

The glazing was the most costly construction item, 32 m2 (330 sq. ft.) cost about $1,400. Other material costs for the greenhouse are a fraction of the material costs for the addition.

The Doyons do not intend to supply heat to the greenhouse in winter to sustain plants. Their solar addition will produce a net heat gain and help heat the rooms in the new addition.

Viewing:

Arrangements to view and discuss the project with the Doyons should be made in advance, telephone—**383-2732.** The demands of their pottery business make them hard to contact at home at times.



Cross-section of addition and greenhouse

Attached Solar Greenhouse

Gary Eikenberry
Short's Lake, Colchester County

Purpose:

The project converts a porch to a solar heated greenhouse for growing vegetables for domestic use. This is an easy project that homeowners can do without assistance.

Description:

The 1.5 m x 2.7 m (5 ft. x 9 ft.) greenhouse was built between the deck and roof of a porch. The walls are of standard stud construction with shingles on the outside and *"Aspenite"* on the interior. The floor is insulated with RSI-1.7 (R-10) rigid foam board, the walls are RSI-2.1 (R-12) fibreglass, and the roof with RSI-3.5 (R-20) fibreglass.

The glazing is a double layer of *"Kalwall"* fibreglass held in place by aluminum nails with neoprene washers and sealed with silicon caulking.

A long, hinged board beneath the eaves is used for ventilation. In winter, excess heat in the greenhouse will be vented through the window to the house to reduce home heating costs. When the temperature falls too low, the greenhouse will be heated by the home's heating system. Thermal mass will moderate temperatures within the structure.

To save floor space, a planned 100 L water filled oil drum for heat storage was replaced with a concrete block wall, painted black and filled with moist sand. Mr. Eikenberry used this system in his cold frame and found it worked well.

Performance:

The winter before construction, Mr. Eikenberry marked the shadow produced by the porch roof on the house wall to determine the solar exposure the plants would get. He used this information to position the glazing.

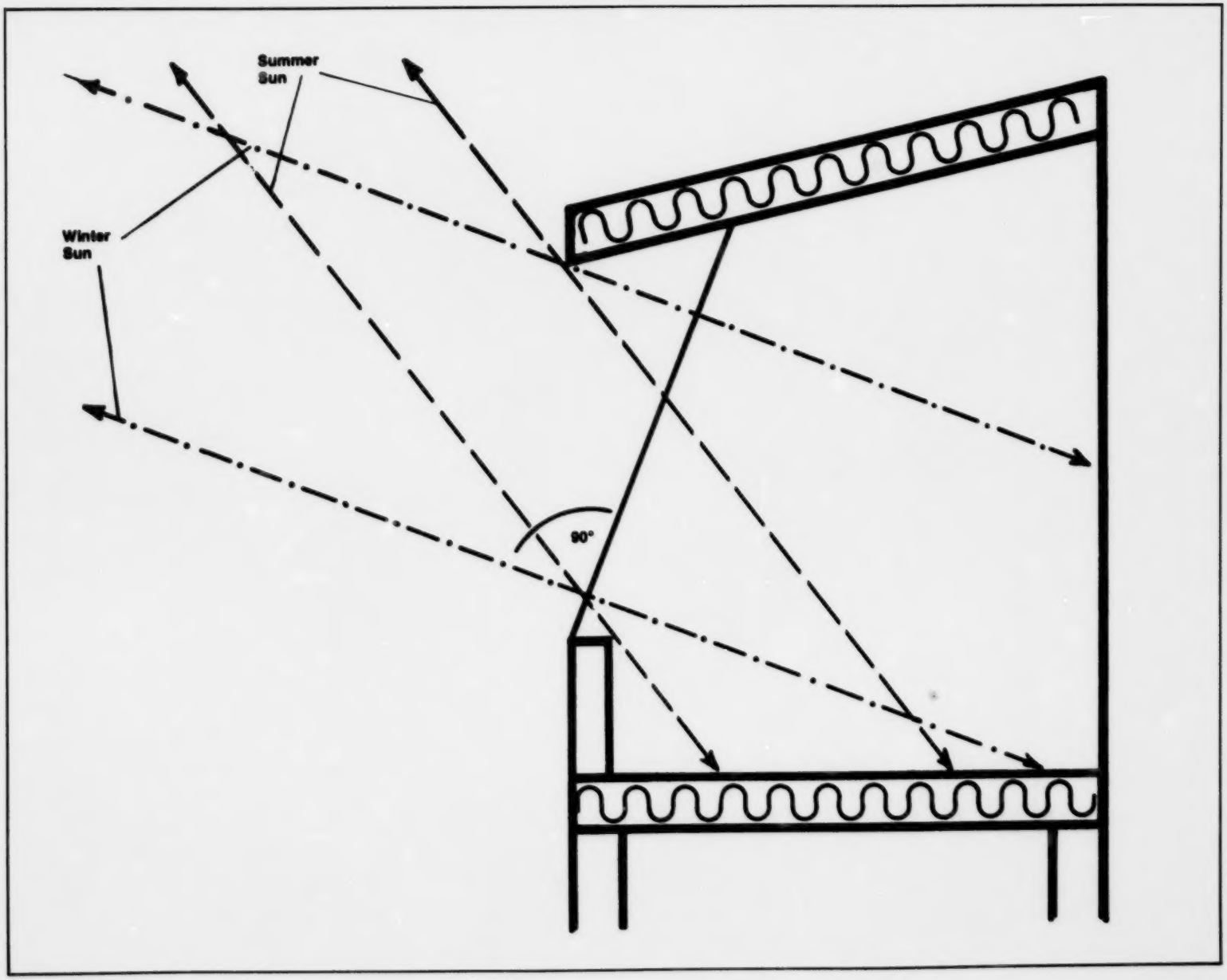
Greenhouse conversion of porch

Comments:

When converting an existing structure to passive solar heating, investigate the strength of the structure and its supports. Water filled tanks, masonary walls, and soil filled boxes all bring very heavy loads to bear on the structure. Someone familiar with structural design (an engineer or architect) should be consulted to determine if the building can withstand these loads.

Viewing:

Persons interested in discussing the project with Mr. Eikenberry should make prior arrangements. Telephone—**673-2947.**



Seasonal angle of sun on greenhouse

Attached Greenhouses

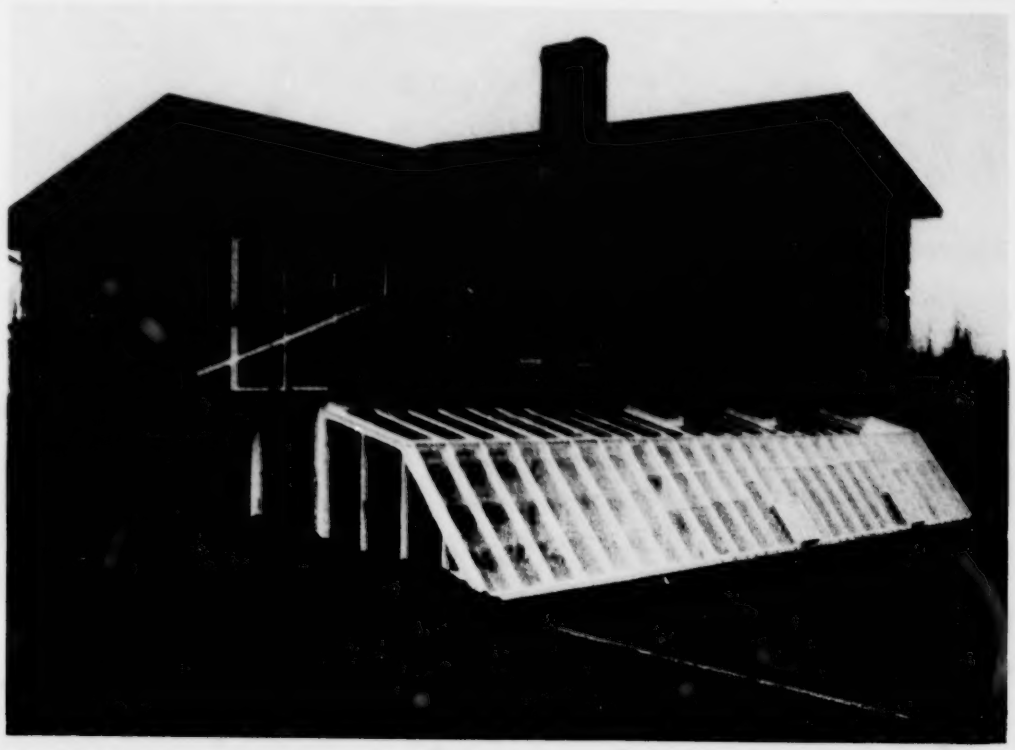
Ken Hill & Quentin Covey
Scotch Village, Hants County

Purpose:

Ken Hill and Quentin Covey have built attached greenhouses for growing vegetables year round on the back (south) side of their houses. Passive solar design techniques minimize heat loss, and wood furnaces in each house supply auxiliary heat.

Description:

The two greenhouses are essentially of identical design with minor variations in detail. The greenhouses measure 9.4 m x 3.1 m (30 ft. x 10 ft.). Each is built on a concrete block foundation with a concrete floor. Fifty mm (2 in.) of rigid foam insulation was placed on the outside of the foundation walls and beneath the concrete floor. This reduces heat loss, and brings the thermal mass of the concrete into the building.



Exterior view of Ken Hill's Greenhouse

The upper greenhouse structure is built of 50 mm x 100 mm (2 x 4 in.) lumber, rabbetted on the edges to hold the glazing. The glazing consists of panes of glass from an old greenhouse, plate glass and several pieces of *"Lexan"*, all collected over a period of time. Silicon and Mono caulkings seal the glazing on the outside and inside respectively. Vent holes, drilled in the bottom of the window framing, allow less humid outside air between the glass to reduce condensation.

"Solarvent" devices operate five vents in each greenhouse. These devices open the vents automatically, without auxiliary power, when the temperature inside the greenhouse reaches 18°C to 24°C (65°F to 75°F), depending on the weight of the vent. When the air temperature decreases, springs pull the vent closed. Latch hooks ensure the vents stay closed during the winter. Each greenhouse has about 1.7 m^2 (17 sq. ft.) of vent.

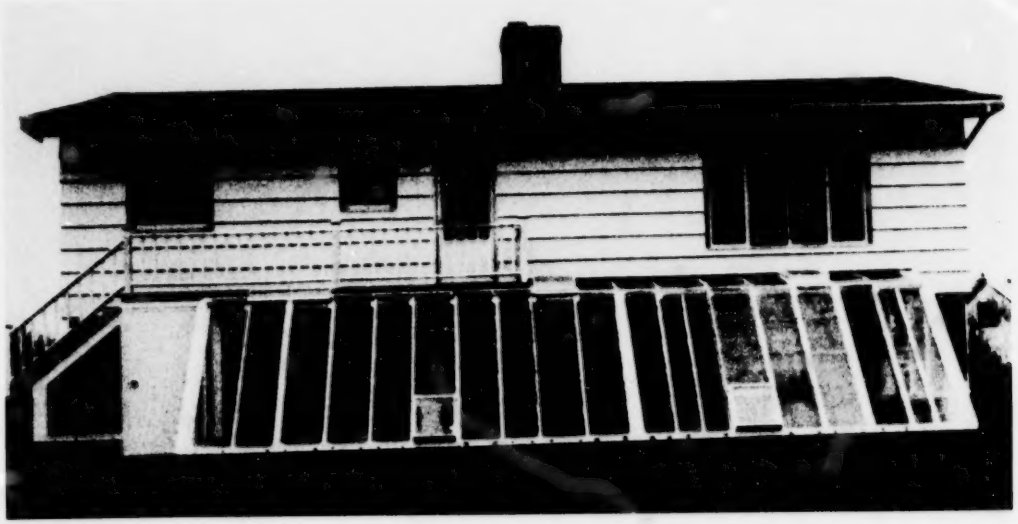
Five hundred, 4.5 L (1 gal.) plastic bottles, as well as some 231 23 L (5 gal.) pails, obtained from a paint supplier, provide thermal storage.

Mr. Hill's greenhouse has a fully glazed, air lock entrance. Firewood for the furnace is stored here before its taken into the basement to be burned. Mr. Covey's greenhouse has a wooden double entrance for year-round use and a separate aluminum door for summer access to the outdoor garden.

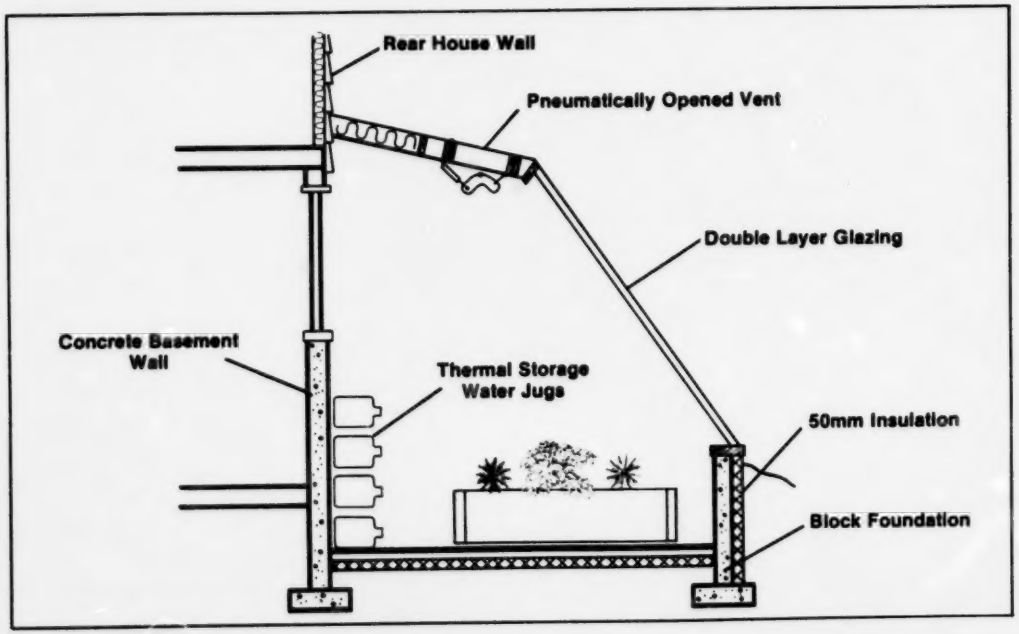
Economics & Performance:

The two greenhouses cost approximately $8,500 of which $4,750 was granted under the Small Scale Energy Demonstration Program. Used glazing materials lowered costs substantially.

Both men cut the wood for their furnaces from their 3.2 ha (80 acre) wood lot, making the added cost of heating the greenhouses a minor concern. The two greenhouses are well built, relatively air-tight buildings that will require much less energy than the conventional, draughty greenhouses.



Exterior view of Quentin Covey's Greenhouse



Cross-section of Hill and Covey Greenhouses

Viewing:

Persons who wish to see the greenhouses should telephone Mr. Covey to make arrangements at **757-2781.**

Attached Solar Greenhouse

Lorna and Donald Knight
Margaree Valley, Inverness County

Purpose:

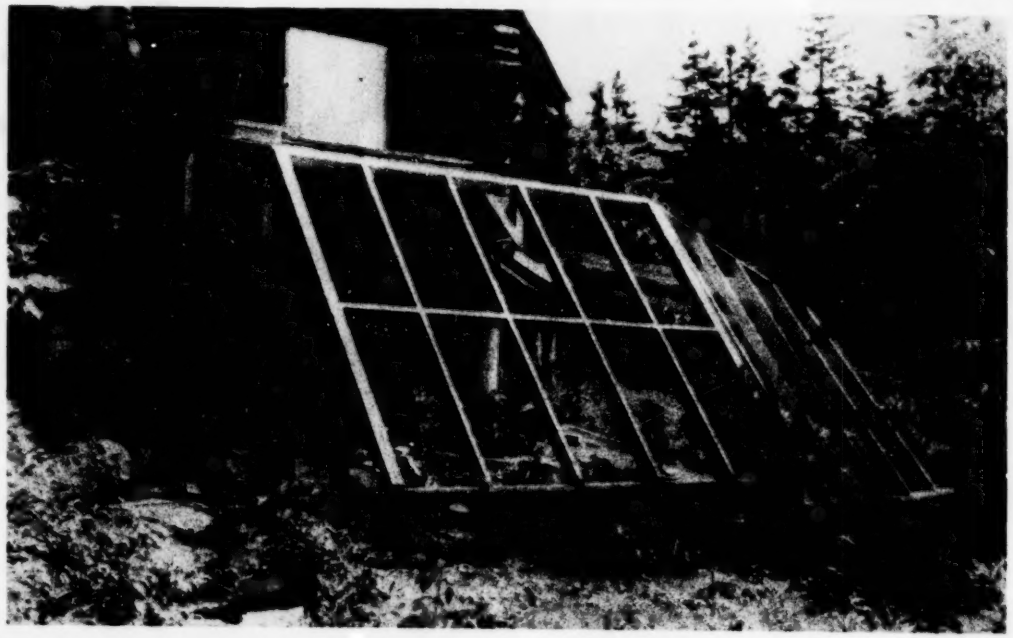
The Knights plan to show that a passively heated, attached solar greenhouse is practical in the Cape Breton climate. The greenhouse will extend the growing season by sustaining plants in early spring and late fall.

Description:

The three section greenhouse is attached to two faces of the Knight's octagonal house. The greenhouse is 3.7 m (12 ft.) deep, has a perimeter length of 10.7 m (35 ft.), and a maximum internal height of 2.8 m (9 ft.). The foundation consists of posts on footings extended below the frost line. Beams laid on the posts form the front perimeter. Insulation is placed vertically in front of the beams and backfilled with earth. The remainder of the frame is constructed of 50 mm x 100 mm, (2 in. x 4 in.) coppernaphthenate-treated lumber. Planks and roof shingles cover approximately one-third of the roof; the remainder is glazed. The north wall and roof areas are insulated with 88 mm (3.5 in.) of fibreglass (RSI-2.1).

"Lumar Polyester Film" is used for glazing. This clear material was chosen because it will not obstruct outward vision. A 7 mil layer is used on the outside and a 5 mil layer on the inside.

A reflective backed, window quilt, slides down guy-wires running from the roof to the base of the glazing. This quilt keeps heat in the greenhouse at night. A propane space heater provides back-up heat during extended periods of cloudy weather.



Frame of greenhouse during construction

One window in the north wall, two vents in the roof, and the access door in the east wall provide convective ventilation to prevent greenhouse overheating during the summer. In the spring and fall, excess heat from the greenhouse is vented into the livingroom through four rectangular vents in the house wall. If necessary, a battery powered, reversible fan will be installed to move the hot air between the greenhouse and the livingroom.

Crops will be grown in the earth floor of the greenhouse. The hill on which the house and greenhouse are built will allow a terraced garden design.

Heat storage is provided by a row of eight, 207 L (45 gal.) oil drums set under the edge of the house. Since the house is built on posts, these drums can be set back out of the growing area and still be fully exposed to the sun.

Performance:

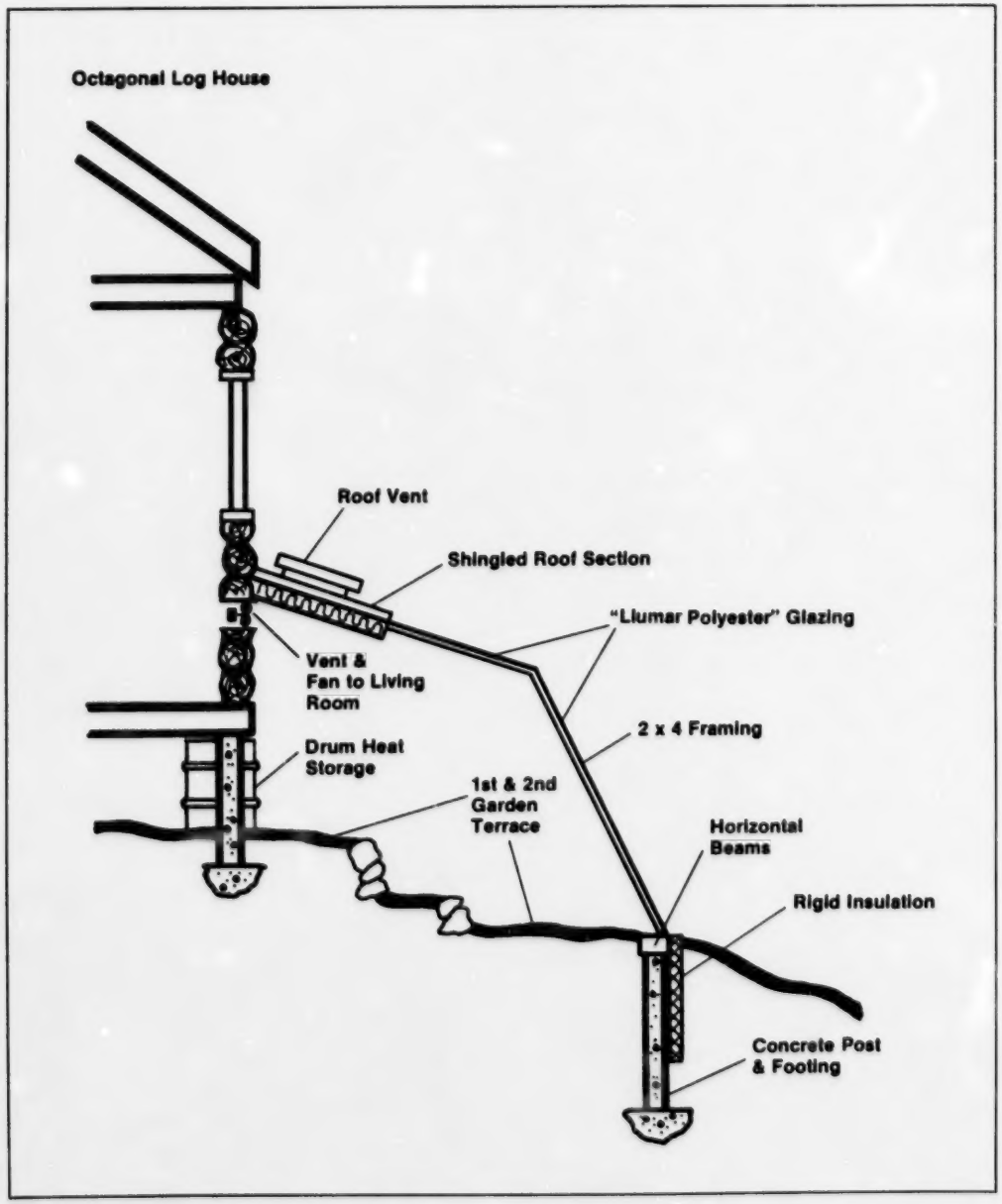
Temperatures inside the greenhouse will be recorded with mechanical, min-max thermometers. Since the Knights do not plan to grow plants during the winter months, the greenhouse should produce a net energy gain over the year.

Economics:

The basic greenhouse structure cost approximately $2200. The polyester glazing was considerably less expensive than fibreglass but its performance is not well documented.

Comments:

The Knights are interested in sharing their knowledge and experiences with others and conducted a two-day seminar for ten people during construction of the greenhouse.



Sectional view of house and greenhouse

The seminar weekend cost approximately $600. Of those who attended, two couples built their own greenhouses in 1982.

The Knights advertised their weekend in local English and French newspapers. They received more than 20 applications, but could accommodate only ten people.

A local carpenter provided carpentry instruction, while Donald Knight showed slides and a movie dealing with passive solar greenhouses. Participants helped build the greenhouse frame but time didn't permit installation of the polyester film glazing.

Viewing:

Visitors are more than welcome. Arrangements should be made in advance by mail.

C. Donald Knight
R.R. No. 1, Box 10
Margaree Valley, Nova Scotia
B0E 2C0

Solar Heated Greenhouse Sunspace

Ron MacInnis
Pereau, Kings County

Purpose:

The sunspace was intended to be an attached greenhouse that anyone could build as an inexpensive, weekend project. The structure is meant to be removed during the summer.

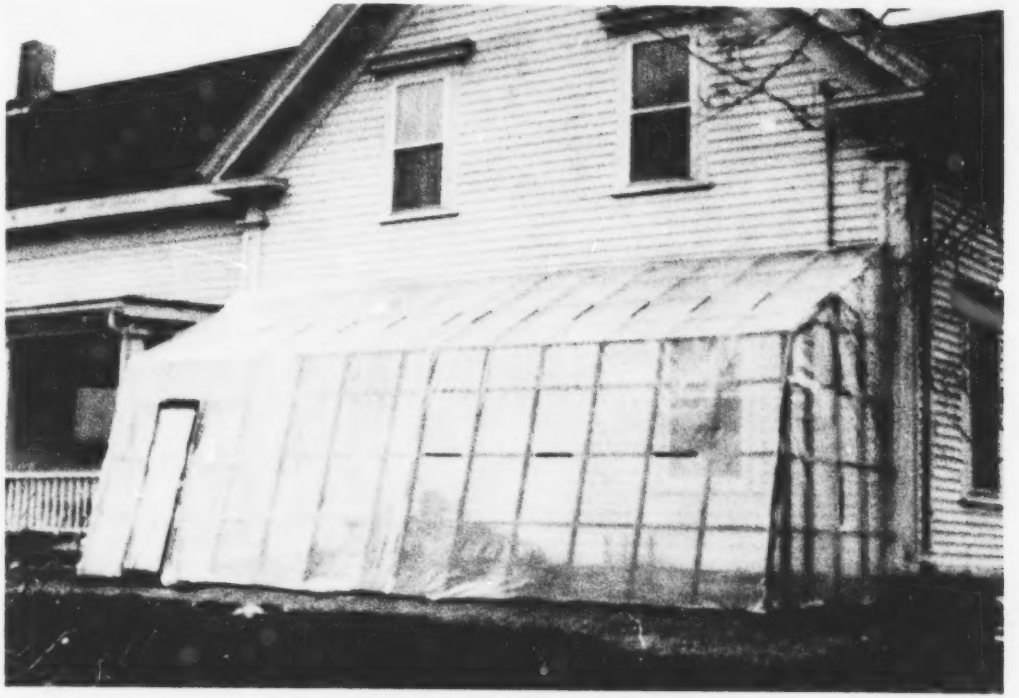
The sunspace acts as a greenhouse, solar collector, and recreation area. Mr. MacInnis reports that his collector is of great psychological benefit when he is suffering from the "mid-winter blues".

Description:

The first sunspace collector Mr. MacInnis built was a straight, slope-sided structure with very little headroom. It used a double layer of vapour barrier plastic for glazing. The performance was sufficient to encourage Mr. MacInnis to further develop his design.

The second sunspace was intended to test a hoop-shaped frame design. The sunspace is a 7.6 m x 3.1 m (25 ft. x 10 ft.) bent wood frame structure constructed of 1/4 circle hoops made from 50 mm (2 in.) wide plywood strips separated by 50 mm x 50 mm (2 in. x 2 in.) blocks. The hoops are fastened between a 50 mm x 50 mm (2 in. x 2 in.) board on the side of the house, above the windows, and a 50 mm x 150 mm (2 in. x 6 in.) frame on the ground. The end walls are framed with 25 mm x 75 mm (1 in. x 3 in.) board. Glazing consists of a single layer of 6 mil vapour barrier, held on with staples and small plywood strips.

The structure was sealed against the house by a flashing along the top (plastic pushed up under the shingles), loose fibreglass insulation along the sides, and by earth piled over the bottom edge of the plastic.



Mr. MacInnis' third sunspace

Heat can be exchanged with the house via two window ducts and a door.

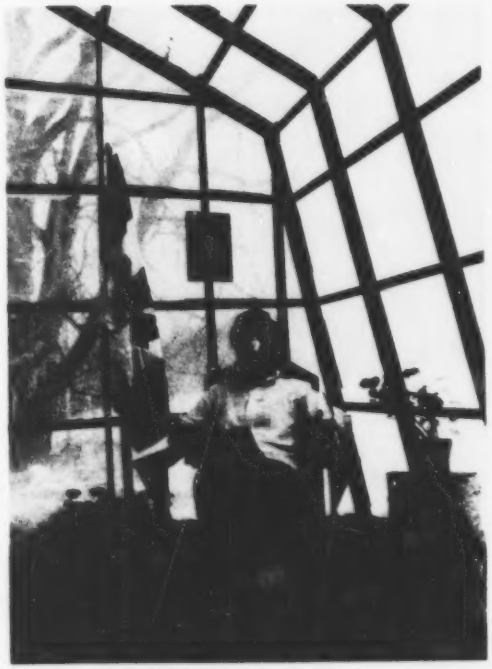
The third sunspace will use 25 mm x 75 mm (1 in. x 3 in.) wood stripping for the frame, and has two slope, straight-sided walls for ease of construction and for headroom. Double layer vinyl will be used for glazing. The vinyl is transparent, so the view through the collector won't be distorted.

Ventilation ducts will be installed on the end walls of the sunspace and will be controlled by bi-metallic closers. Heat will be stored in water-filled, plastic jugs. An electric heating cable will be placed in the plant bed soil. This thermostatically controlled heating system will incorporate an electric clock to record the length of time heat is required.

Performance:

The first sunspace produced a net heat gain with the excess used to help heat the house. It is estimated that the sunspace reduced the heating bill over one winter by $150.

The second sunspace proved the value of the double plastic glazing. With single glazing, instead of the double, the temperature inside the sunspace dropped lower and more quickly at night. The bent-wood frame works well if good quality plywood is used. Plywood with too few laminations or poor quality glue will separate or crack when bent.



Mr. MacInnis enjoying his third sunspace

The performance of the third sunspace is expected to exceed that of the first.

Economics:

Mr. MacInnis estimated that the first sunspace paid for itself in one winter in lower heating costs.

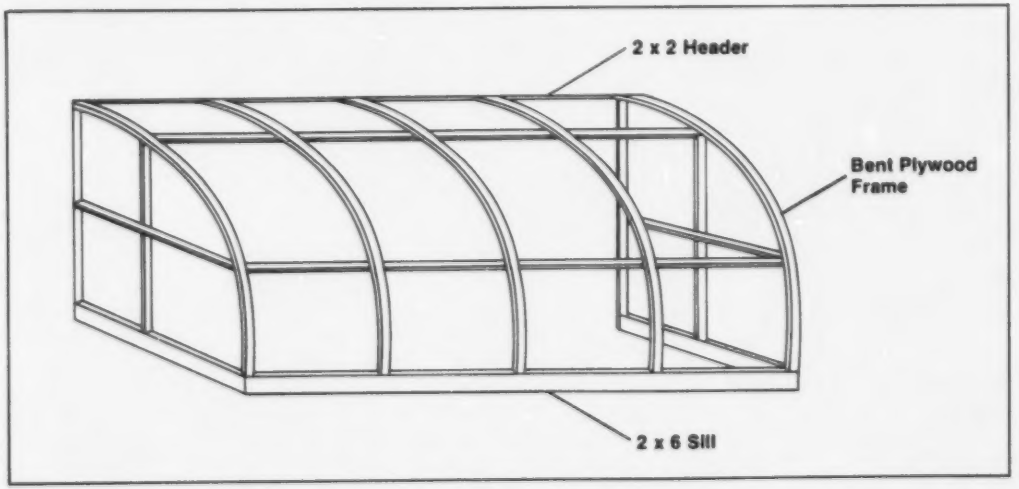
The third sunspace will be more expensive to build and mean alterations to the house for better use of the sunspace. It is hoped that its improved performance will pay for itself in one year as well. Mr. MacInnis will keep records of time spent gardening in the sunspace to determine the value of his crops.

The cost of building a sunspace will depend on the size and degree of sophistication. A small, simple model could easily be built for under $200, making it an inexpensive greenhouse.

Mr. MacInnis planned to produce a small publication describing his design and construction techniques.

Viewing:

Visitors are welcome provided they call in advance to make arrangements home: **582-3051;** work: **424-3591.**



Design of sunspace number two

Solar Heated Room

Everett MacLeod
Kentville, Kings County

Purpose:

The solar heated room is intended to produce hot air to partially heat the MacLeod home. It will also be used as a greenhouse and recreation area.

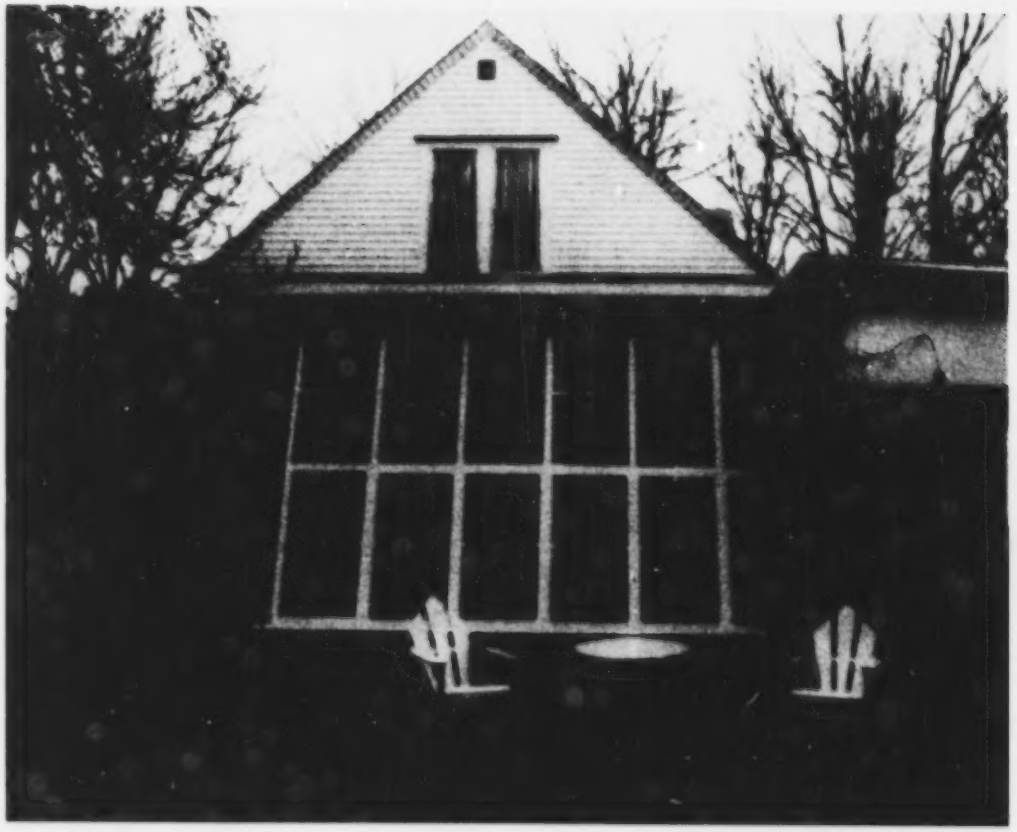
During the coldest months of the winter, when the air inside the room is not hot enough to heat the house or sustain plants, the room will serve as a wind break and insulation layer, reducing heat loss from house walls.

Description:

Mr. MacLeod's solar room is constructed under an existing roof between a back porch and the side of the carport. The foundation is made of a 1 m (3 ft.) high concrete block wall, insulated with two, 50 mm (2 inch) layers of rigid foam insulation. The hollow core of the blocks is filled with shredded foam insulation.

The south wall is framed with 50 mm x 150 mm (2 in. x 6 in.) lumber running from the foundation wall to the existing porch roof header. Glazing consists of salvaged storm windows. Windows in good condition were put on the outside. The glass was removed from the remaining frames and mounted directly between the studs, on the inside.

Thermal storage consists of a below grade pit filled with 14,500 kg (16 tons) of river rock. The pit walls are the same construction as the foundation walls, and are lined with insulation, vapour barrier, and plywood. The earth floor of the pit is also insulated. Perforated plastic pipes, protected in plywood and brick tunnels, distribute hot air through the rocks. A small fan takes hot air from the roof peak and forces it through the pipes and rock storage.



Rear View of Solar Room

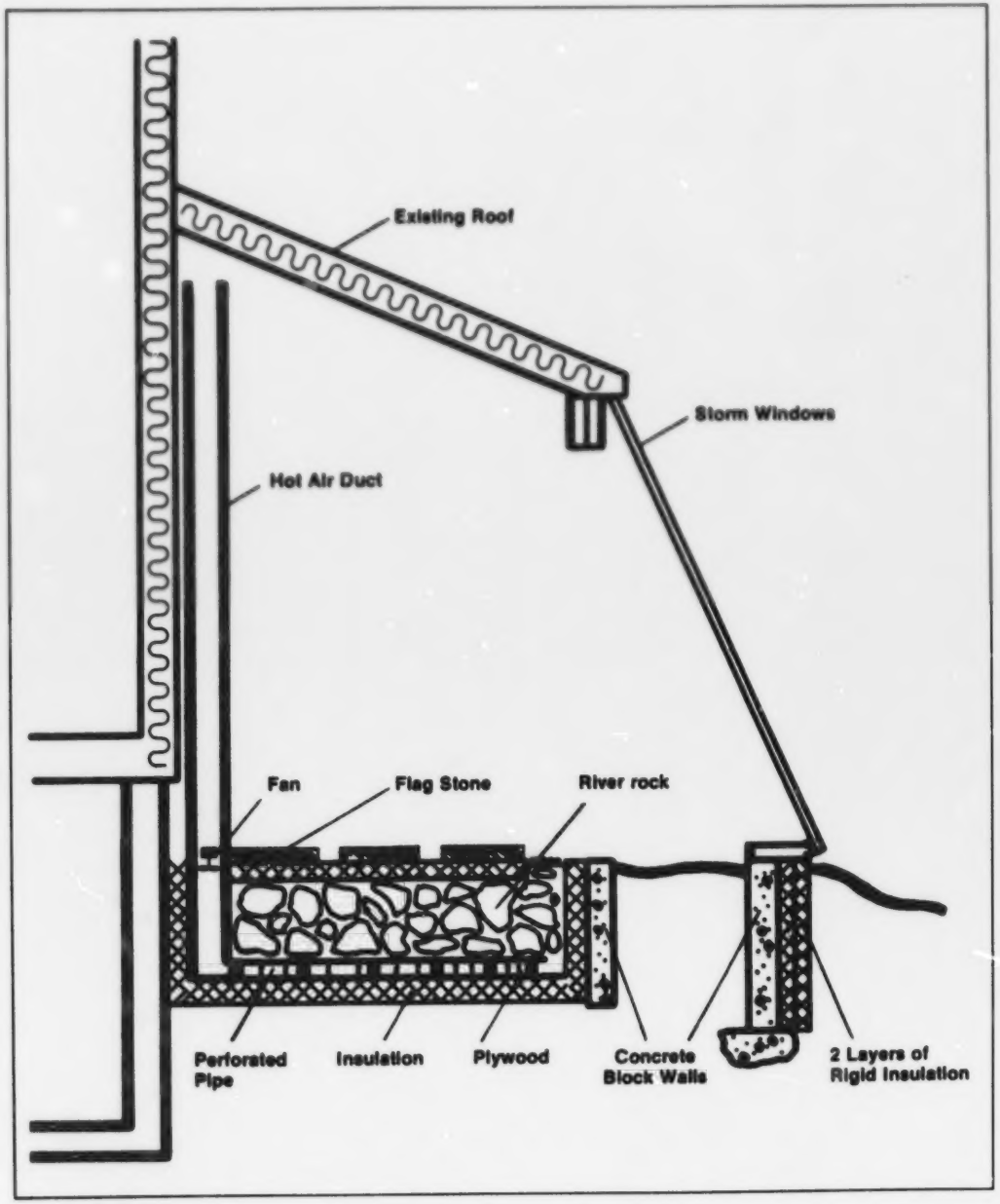
The end wall and roof of the room are insulated with 150 mm (6 in.) of fibreglass insulation placed between 50 mm x 150 mm (2 x 6 in.) frame members.

Several of the front windows and a door in the carport wall open to provide summer cooling and ventilation.

Mr. MacLeod hopes to build a movable solid insulation panel system to cover the windows at night to reduce heat loss. The system will be powered by a 12 volt motor from automotive electric window raisers.

Performance:

Mr. MacLeod realizes that the temperature inside the solar room may not always be above freezing. He is not planning to supply heat to the room in order to maintain plants but rather hopes, when possible, to draw heat from the room and reduce his heating oil bills.



Cross-section of solar room

Economic Analysis:

The materials and hired labour for the solar room cost about $1,500. The actual performance of the room is unknown. Mr. MacLeod hopes it will reduce his oil consumption by about $250 annually.

Mr. MacLeod plans to build a solar water heating system to further reduce fuel oil costs.

Viewing:

Persons interested in talking with Mr. MacLeod about his solar project are asked to telephone **678-4750.**

Attached Solar Greenhouse

Orval Meisner
South Brookfield, Queens County

Purpose:

The attached greenhouse structure will be used to extend the growing season and to provide supplementary heat to the Meisner's 130-year-old farmhouse.

Description:

The greenhouse is built on the southwest corner of the house. It measures 7.5 m x 4.7 m (24 ft. x 15 ft.) and is about 4.7 m (15 ft.) high.

It sits on a concrete block foundation, insulated with 50 mm (2 in.) of rigid foam insulation on the outside. The foundation is filled with washed 75 mm (3 in.) crushed stone. Two, 15 mm (6 in.) diameter plastic pipes with fans move air from the peak of the roof into the rocks. Once in the rocks, the air simply defuses up into the greenhouse.

Greenhouse on side of Meisner farmhouse

The greenhouse walls are made of 50 mm x 150 mm (2 in. x 6 in.) lumber. All walls are insulated with 150 mm (6 in.) fibreglass batts for an approximate insulation value of RSI-3.5 (R-20).

The main, southern glazing is made of *"Tedlar"* panels. These are made from two layers of *"Tedlar"* film stretched over a steel frame. These panels require support only around their perimeter if mounted on a slope of 45° or more. This metal frame system creates much smaller shadows than a 50 mm x 150 mm (2 in. x 6 in.) wood frame.

The knee wall contains three operable, double glazed, casement windows and two fixed *"Kalwall"* windows. *Kalwall* is also used to make odd-shaped windows on the end walls and a skylight section in the roof. The end walls also contain several fixed, double glazed windows.

Air can be circulated between the greenhouse and the house by a fan mounted in a common wall. Return air is provided through a basement window. Various heating and cooling operations are possible, depending on the fan direction and window position.

A door connects the house and the greenhouse. An outside door was also installed for access to the outside garden.

The crops will be grown in raised beds positioned on top of rock walls. These walls are an extension of the thermal storage system in the floor. The sides of the growing beds are made of three 50 mm x 150 mm (2 in. x 6 in.) boards on edge.

Performance & Economics:

The greenhouse will extend the growing season, storing the sun's energy as latent heat in the rock mass of the floor. This heat will keep the greenhouse warm during spring and fall nights. If insufficient heat is available, the fan will move warm air into the greenhouse. The displaced air from the greenhouse will move into the basement. Heat will only be provided as long as it is economical to continue growing plants.

When plants are not in the greenhouse, the temperature can be allowed to drop below freezing. During sunny winter days, the greenhouse will become very hot. This warm

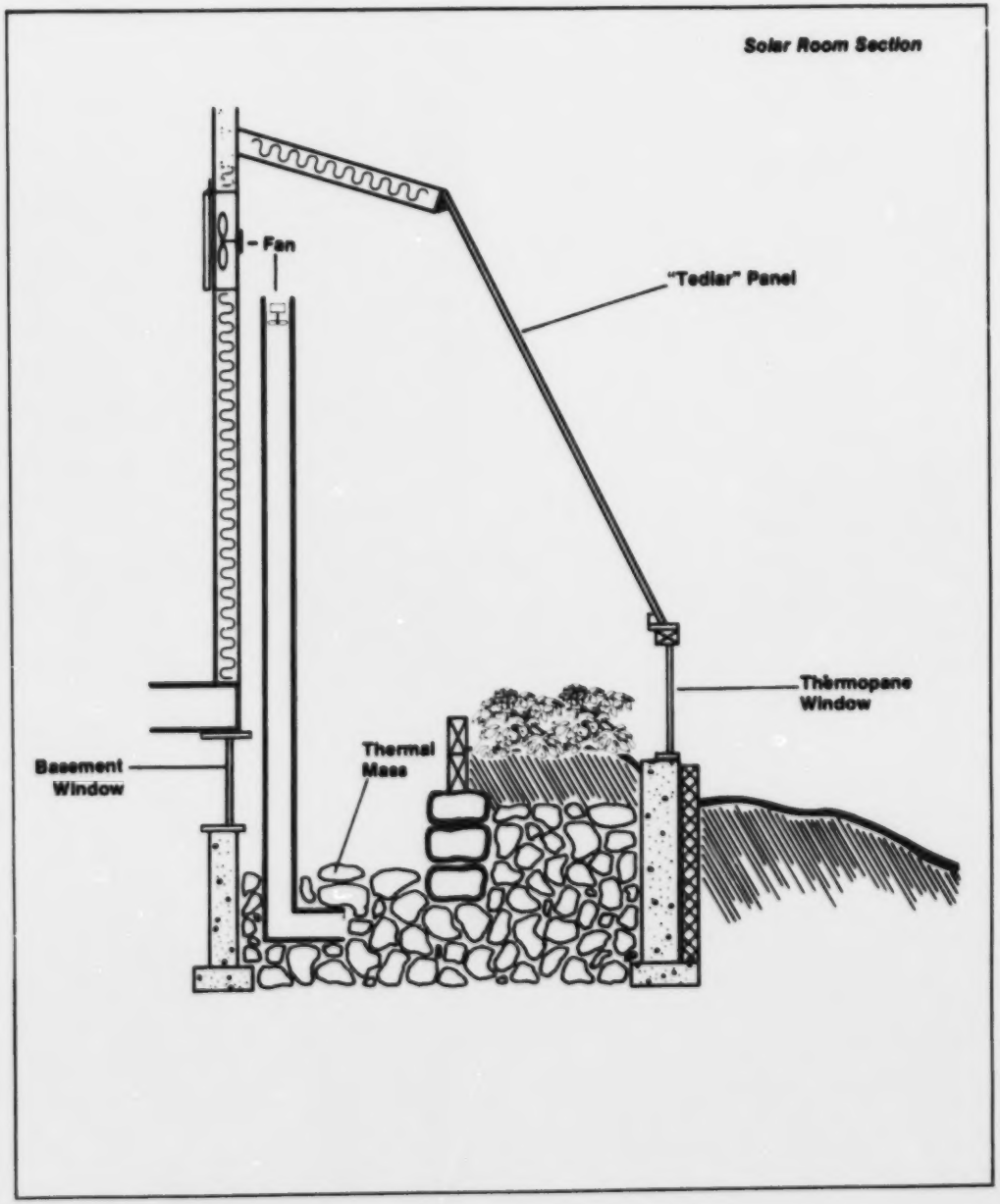
Long View of Growing Beds

air can be drawn into the house as auxiliary heat. If used properly, the greenhouse will produce a significant net heat gain over the winter.

A carpenter was hired to build the greenhouse foundation and framing. The remaining work was performed by the Meisners. The finished greenhouse is well built and is compatible with the house. At a total cost of $4,700, the greenhouse cost $17.00 per sq. ft. of floor area. This is about one-third of conventional construction costs.

Viewing:

Mr. Meisner's home telephone number is **242-2527.** Please telephone to arrange a visit.



Cross-section of greenhouse

Walk-In Solar Collector/ Sunspace

David Miller
Musquodoboit Harbour, Halifax County

Purpose:

The walk-in solar collector supplements the heating requirements of the Millers' 75 year-old house. The collector traps solar energy in the same manner as an attached greenhouse. Warmed air circulates through the house by the hot air furnace's blower.

Description:

The collector structure is built across the front of Mr. Miller's house and extends into the basement, beneath the living room. The structure is 8.4 m (27 ft.) long, 2.5 m (8 ft.) deep, and extends 2.2 m (7 ft.) into the basement.

The collector's foundation is of conventional concrete construction; it was poured over 50 mm (2 in.) of rigid foam insulation to reduce heat loss. All concrete surfaces within the collector and basement section are painted flat black to maximize solar energy absorption. The painted concrete's thermal mass moderates air temperatures within the collector.

The collector frame is made entirely of cedar lumber, rabbetted to permit glass panels to fit flush with its face.

Double layer, tempered glass panels form the glazing. A glass supplier was hired to install the 90 kg (200 lb.) glass sections. Mr. Miller felt the hiring was warranted because of the difficulty of handling the heavy sections and because the supplier would be responsible for any breakage.

Greenhouse of Front of Miller Residence

An automotive type sealant seals the glass in place. White aluminum flashing on the outside covers the joints between the glass sections. Care was taken to ensure that the glass had room to expand and that rain water could drain from under the aluminum trim.

When air within the collector is warmer than air within the house, the thermostat calls for heat. The circulating fan on the hot air furnace draws warm air from the collector and circulates it through the furnace's distribution system. If air in the collector is not warm enough, the furnace will operate normally.

During the summer, large deciduous trees surrounding the collector provide shade to keep the collector cool. An east window and west door open, permitting cross-flow ventilation.

Performance & Economics:

Detailed calculations by a consultant indicate the collector/sunspace may provide 40 per cent of the home's annual heating needs. Historical weather data show that the system probably won't provide a significant amount of heat during the cloudy months of November and December, but will provide significant heat during the sunnier months of January, February and March.

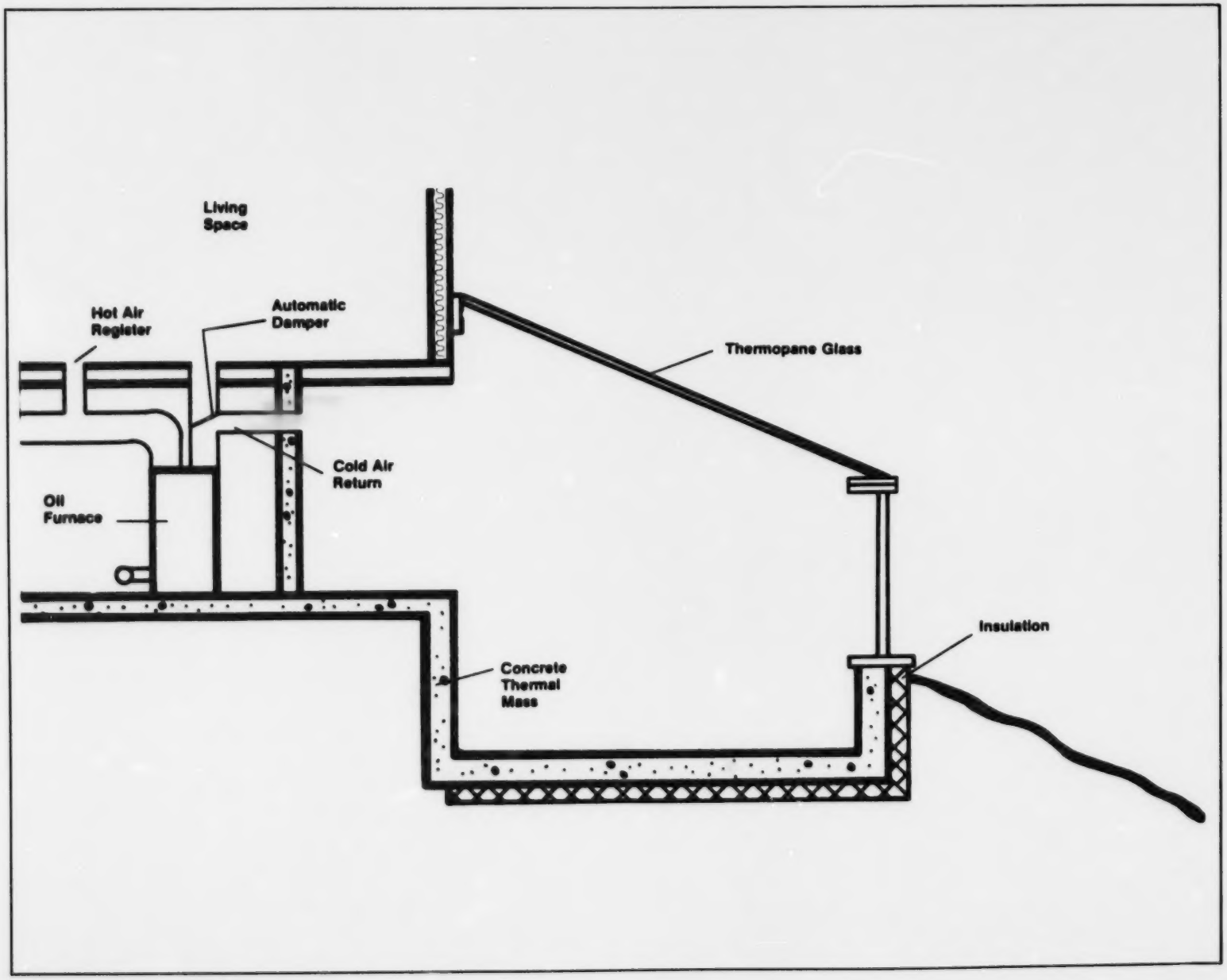
About one-half of the $3,600 cost of the sunspace/collector was spent on glass. Concrete was mixed by hand, reducing costs. The floor space within the sunspace was built for about one-half the cost of normal residential construction.

As a solar collector, the structure will supplement the home heating system. As a sunspace, the structure will provide an area in which to enjoy the winter sun.

The Millers do not plan to keep plants in the structure during winter. They realize that the collector will lose heat and the temperature inside may drop below freezing when the sun is not shining. They anticipate starting transplants in the sunspace early in the spring.

Viewing:

Persons interested in viewing and discussing the collector/sunspace may make arrangements with Mr. Miller at home, telephone—**889-2199.**



Cross-section of greenhouse addition

Attached Solar Greenhouse

Judith Steeves
Springfield, Lunenburg County

Purpose:

This attached greenhouse will supplement home heating as well as produce vegetable crops year round. The supply of fresh oxygen and moisture it provides will be welcome inside the owner's 100-year-old farmhouse.

Description:

The greenhouse is 6.1 m long x 2.4 m wide (20 ft. x 8 ft.) with 3 m x 6.1 m (10 ft. x 20 ft.) of glazing. It is attached to the south wall of the house, where an existing porch provides access.

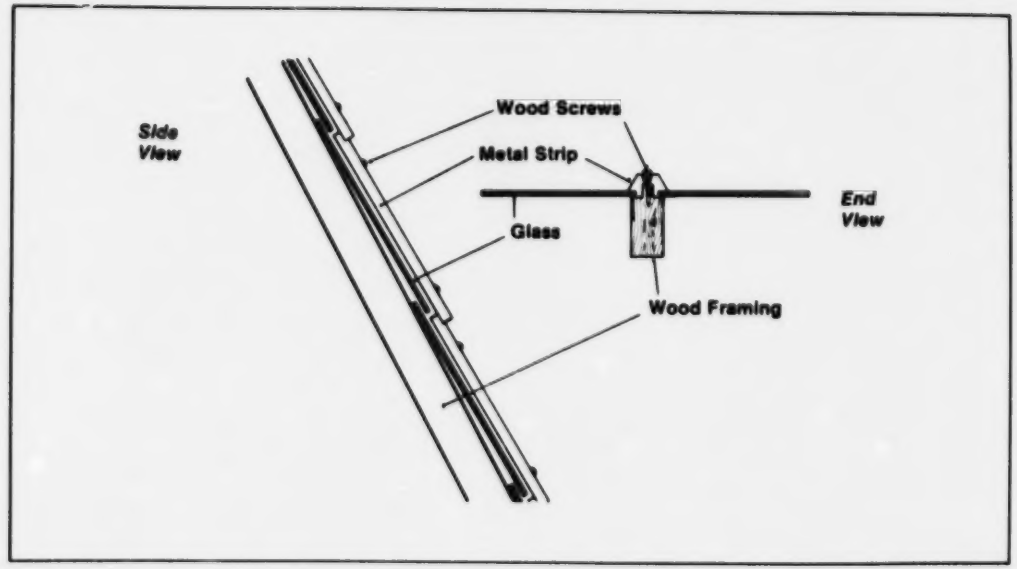
The greenhouse stands on concrete posts. A wall was built between the posts consisting of 150 mm (6 in.) of rigid insulation for the first 600 mm (2 ft.) of depth and 100 mm (4 in.) between 2 m (6 ft.) and 1.2 m (4 ft.) of depth. The outside of this wall was covered with galvanized metal.

The frame of the greenhouse was built of truss sections. Each truss has plywood gussets for added strength. One hundred fifty mm (6 in.) of fibreglass insulation was used on the end wall and roof.

The glass was obtained from a commercial greenhouse that was being demolished. Each 500 mm (20 in.) square pane fits into a rabbetted groove in the 50 mm x 300 mm (2 in. x 6 in.) truss frame. Metal strips hold the glass in place.

The glazing has a steep slope (70°) to increase winter solar gain and decrease summer solar gain. The steep slope also ensures that snow won't collect on the glazing. The short roof section of the greenhouse blends into the roof

Side view of Steeves' Greenhouse



Glazing System

of the porch, making the greenhouse an attractive structure.

The inside of the greenhouse was excavated below the outside grade, exposing the thick rock foundation of the house. Approximately 1.2 m (4 ft.) of loose rock is used for the walkway. The exposed foundation and rock walkway serves as passive heat storage.

Heated air circulates between the greenhouse and the house via a basement window and two wall windows. Additional vents may be installed leading into second-floor bedrooms.

Performance:

During June and early July 1981, the structure did not overheat. This may be due to the steep glazing slope or the fact that the greenhouse was not then sealed tightly to the side of the house. An automatic vent will be installed on the leeward wall to ensure adequate ventilation.

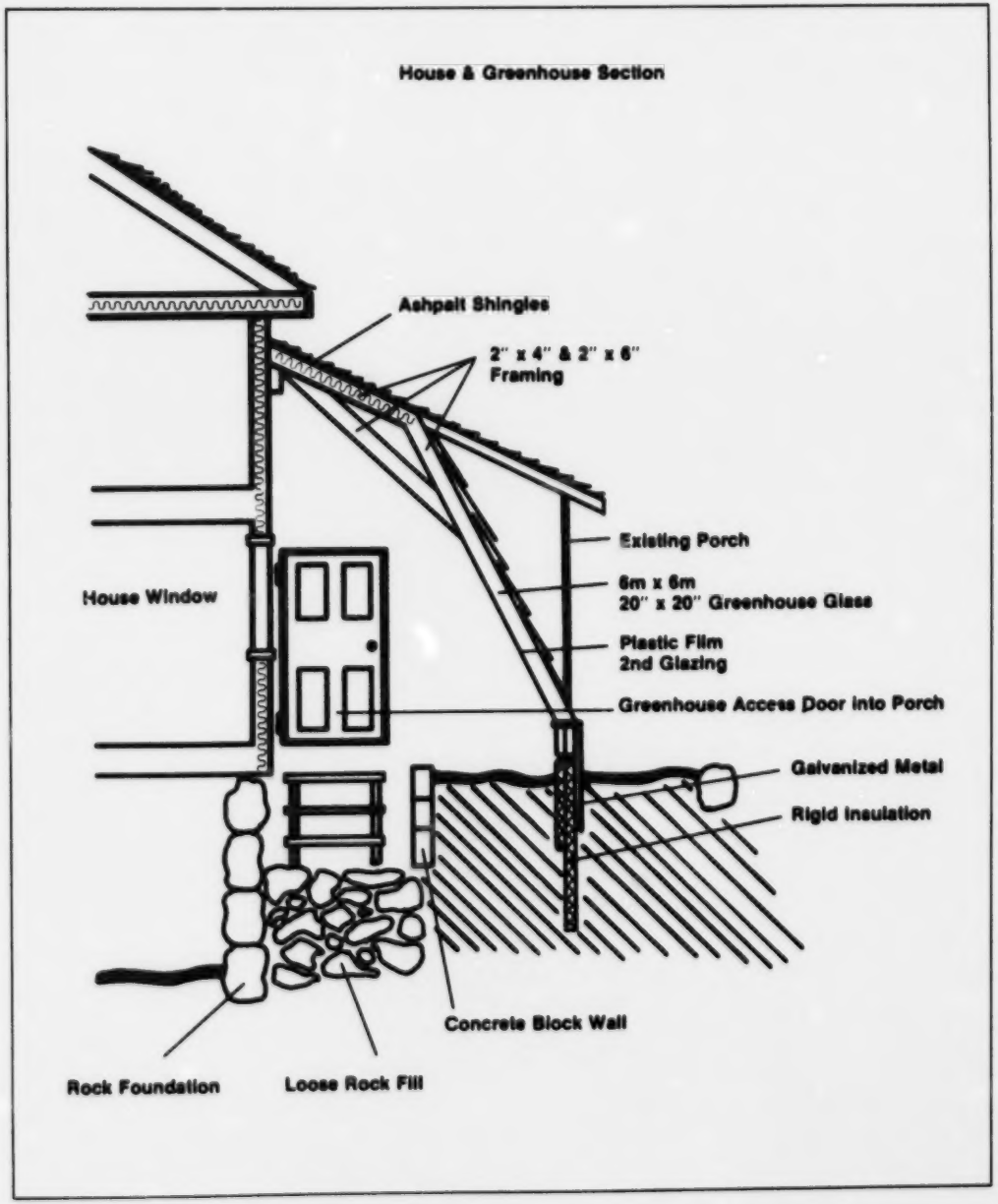
Economics:

The greenhouse cost about $1000. The excavation work was done by hand and was, therefore, very time consuming. The glazing was obtained at a very reasonable cost, while the remainder of the materials were purchased new.

Judith Steeves says that she would have built the greenhouse eventually, but a Small Scale Energy Demonstration Program grant enabled her to proceed more rapidly.

Viewing:

Those interested in talking with Judith about her greenhouse should telephone to make arrangements. Her home number is **547-2779.**



Cross-section of Greenhouse

Attached Solar Greenhouse/ Sunspace

John Wilson
Windsor, Hants County

Purpose:

The Wilsons' attached, solar heated structure is intended to serve three purposes: first, as a greenhouse, to extend the growing season; second, as a sunspace or sitting area, to permit one to enjoy the sun on a cold, winter day; finally, to provide auxiliary heat for the house.

Description:

The Wilsons' bungalow, built in 1967, sits on a hill. The front (north) of the house is at ground level while the rear (south) basement wall is above ground and is made of normal wood frame construction.

The 6.3 m x 1.3 m (20 ft. x 4 ft.) greenhouse is built along the rear of the house. It has a 1.25 m (4 ft.) deep foundation filled with rock. This thermal storage pit is covered with a concrete floor that has 9 pipes running through it. On a sunny day, hot air from the greenhouse roof is forced through the pipes into the rock storage, the displaced air flowing up through the larger pipes. When additional heat is required, cool air from the greenhouse will be forced into the rock storage where it will be warmed and then returned to the greenhouse.

The outside of the foundation has been insulated with 50 mm (2 in.) of **"Styrofoam SM"**, rigid foam insulation. All insulation above grade has been carefully covered with white aluminum flashing to protect it from the sun's ultraviolet radiation.

The rear basement wall was replaced with posts and a new wall built 1.9 m (6 ft.) into the basement. This reduces heat loss and simplifies warm air distribution.

The lean-to frame of the greenhouse is made of double cedar (2 x 4 in.) 50 mm x 100 mm boards, rabbetted on the top edges to accept the glazing. The main glazing is imperfect, patio door glass. These units have heat treated, 6 mil, thermopane glass. Normal double glazed windows are used in the knee and east walls.

The west wall contains two, 460 mm (18 in.) vents.

The glazing is secured to the framing by aluminum and beveled cedar strips. Mr. Wilson's attention to detail shows in the fine fit of the exterior trim, making this greenhouse very attractive.

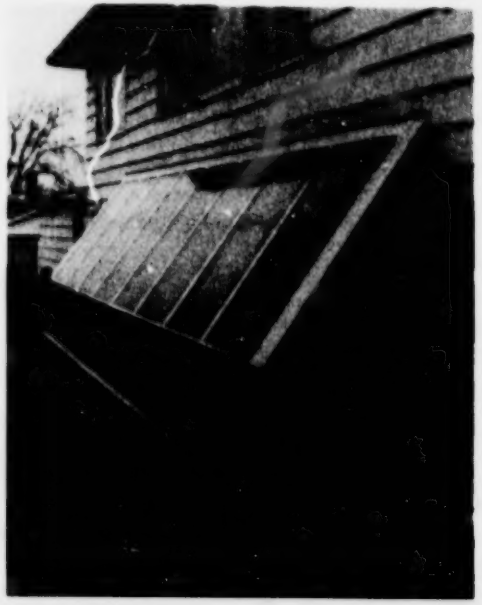
Performance & Economics:

The structure will be monitored to determine how the heat it generates may best be used. The structure is designed for easy air circulation between the greenhouse and the bedrooms on the north side of the house. This heated air will supplement the home's wood-oil furnace. Minimum night-time temperatures will be monitored to determine how long plants can be kept in the greenhouse without auxiliary heat.

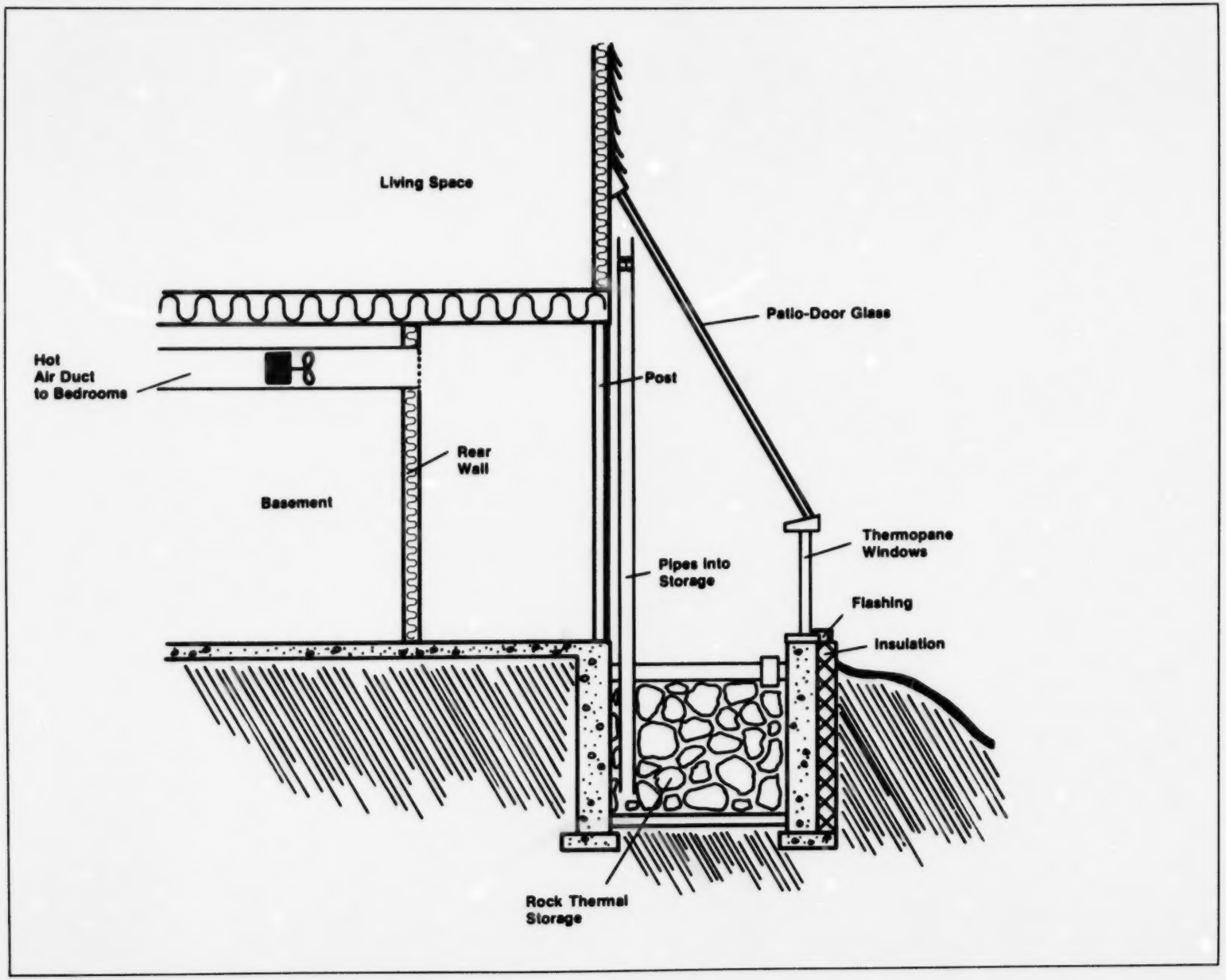
The quality of materials and workmanship make this $4,700 project a valuable addition to the home.

Viewing:

Those who wish to view the project should telephone to make arrangements—**798-2823.**



End View of Greenhouse



Cross-section

Wind Power

3

Generating electricity from the wind using small scale wind generators can be, and usually is, an expensive proposition and one not without its perils. Two words of caution are in order for the casual reader: wind power is expensive and is definitely not for everyone.

On the other hand, the development or purchase of a wind energy system can be a rewarding experience and can provide a large degree of independence from fossil fuels and the utilities that supply electric power to the majority of consumers.

In Nova Scotia, we are blessed with some of the highest average wind speeds in Canada. The coastal areas of the province, as a result of sea breezes and the movement of weather systems, are especially well suited to the generation of power from the wind. At Shearwater, near Halifax, data collected during a 20 year period showed winds of 11-19 km/h (7 to 12 mph) 37% of the time, winds 21-27 km/h (13-17 mph) 20% of the time, and winds of 29-37 km/h (18 to 23 mph) 15% of the time. Most modern wind turbines reach maximum output at wind speeds of 24-48 km/h (15-30 mph).

The most common application for wind power is the production of electricity for domestic uses and/or home heating. Most wind energy systems in Nova Scotia, with the exception of those owned by major utilities, serve these purposes.

When a consumer can purchase energy from the Nova Scotia Power Corporation (NSPC) at the normal domestic rate, wind generators are not economical, and they will not become economical unless there is a great reduction in their cost, a great increase in NSPC rates, or both. Although there are no fuel costs associated with wind power, it is important to note the high initial cost.

The wind energy systems described in the following pages include home-built and purchased systems. Several were built to provide electricity where the cost of connecting to the NSPC grid rivaled that of a wind generator.

The cost and efficiency of the wind energy system funded under the Small Scale Energy Demonstration Program varies greatly.

The homemade Savonius rotor built by Susan and Thomas Aiken, Tatamagouche, is expensive when measured against the amount of electricity produced. This design is not especially efficient for producing electrical energy. The system supplies electricity where a connection to the provincial grid does not exist.

The system installed by Mr. Ross Bunnell, Hemford, Lunenburg County, is an example of an efficient but costly wind energy system. The 5 kilowatt horizontal axis wind generator provides more electricity than can be handled by the current battery bank.

Since winds of sufficient speeds to generate power rarely coincide with electrical demand, deep-cycle lead acid batteries are used to store the generated electricity until it is needed. Many conventional power tools and small appliances will run on 100 volt direct current (DC) power from a DC windmill or battery bank. (Often AC switches must be replaced before an appliance can be used with DC electricity.) Alternatively, by using a DC-AC inverter, one can power all of the conventional devices designed to be powered by utility, or alternating current (AC), electricity.

Wind energy systems can generate either AC or DC electricity. DC electricity must be generated if battery storage is desired. AC electricity cannot be directly stored in batteries. They can, however, be made compatible with the NSPC grid. The provincial utility then serves the role of a backup source of power.

Making the optimum use of the electricity generated by a wind energy system is an often difficult and expensive proposition. Extra batteries, DC-AC inverters, and other equipment required to accomplish this add to the expense of the system. Mr. Bunnell's system cost more than $16,000, but it is one of the most efficient operating in Nova Scotia, and it supplies ample amounts of electricity.

Terry Henderson, of Baddeck, was one of a number of Small Scale Energy Demonstration Program grant recipients to use recycled materials to substantially reduce the cost of acquiring a wind energy system. This 2 kilowatt system was purchased as a used unit and substantially overhauled, reducing Mr. Henderson's cost to about $3,300. The unit generates electricity in excess of its rated capacity.

The use of wind-generated electricity for home heating has been demonstrated successfully by James and Sheila Livingston, Lake Charlotte, Halifax County. The twin, 2 kilowatt, horizontal axis generators can heat a modest, energy efficient home.

Ron MacKay, of Sydney, has built a wind system compatible with NSPC's provincial grid to supplement the energy needs of a home and attached greenhouse. Electrical controls are used to ensure constant, 60 cycle per second, 115 volt electrical output during various wind speeds. A generator brake automatically applies itself if utility power is cut off or if wind speed exceeds 64 km/h (40 mph) or drops below 16 km/h (10 mph). This system was moderately expensive, costing approximately $10,000.

Several home-built systems funded under the Small Scale Energy Demonstration Program have encountered problems. These include a Savonius rotor, constructed by Raymond MacKenzie, of Bras d'Or, which vibrates excessively in high winds; and a Darrieus wind turbine, built by Martial L. Thiebaux, of Stewiacke, which suffers from power robbing transmission friction.

Savonius Wind Rotor

Susan and Thomas Aiken
Tatamagouche, Colchester County

Purpose:

The wind energy system consists of a homemade Savonius rotor, pulley drive, generator, and 12 volt, deep cycle batteries. It is intended to produce electricity for domestic use. The home is not serviced by the electrical utility, so the wind rotor system will provide the Aikens' sole source of electricity.

Description:

The wind turbine is a three-tiered, Savonius rotor with each tier staggered by 60°. The rotor blades are made from sheet aluminum, curved to an almost half circle shape. The blades are mounted between 914 mm (3 ft.) diameter, plywood discs. The discs are fastened to a central shelf that is mounted on tapered roller bearings. A pulley system on the bottom of the rotor shaft increases the rotational speed of the shaft by a factor of 36, obtaining sufficient speed for the *"Thermax"* DC generator.

The generator's output is controlled by an automotive-type voltage regulator, and is stored in deep-cycle, 12 volt storage batteries. When charged, these are transported to the house for use.

An anenometer measures the wind speed, while volt and ampere gauges check the electrical output.

Performance:

The rotor requires a 19-24 km/h (12-15 mph) wind to overcome its start-up frictional load (including the belt-drive and generator loads). During a breezy day, the rotor can fully charge one battery. This lasts the Aikens between three to six days. The Aikens have managed to keep their electrical energy demand as low as possible.

Savonius Rotor on Top of Shed

When high winds are forecast, the Aikens' system uses an inner tube tied to the generator pulley to hold the rotor stationary.

Energy and Economic Evaluation:

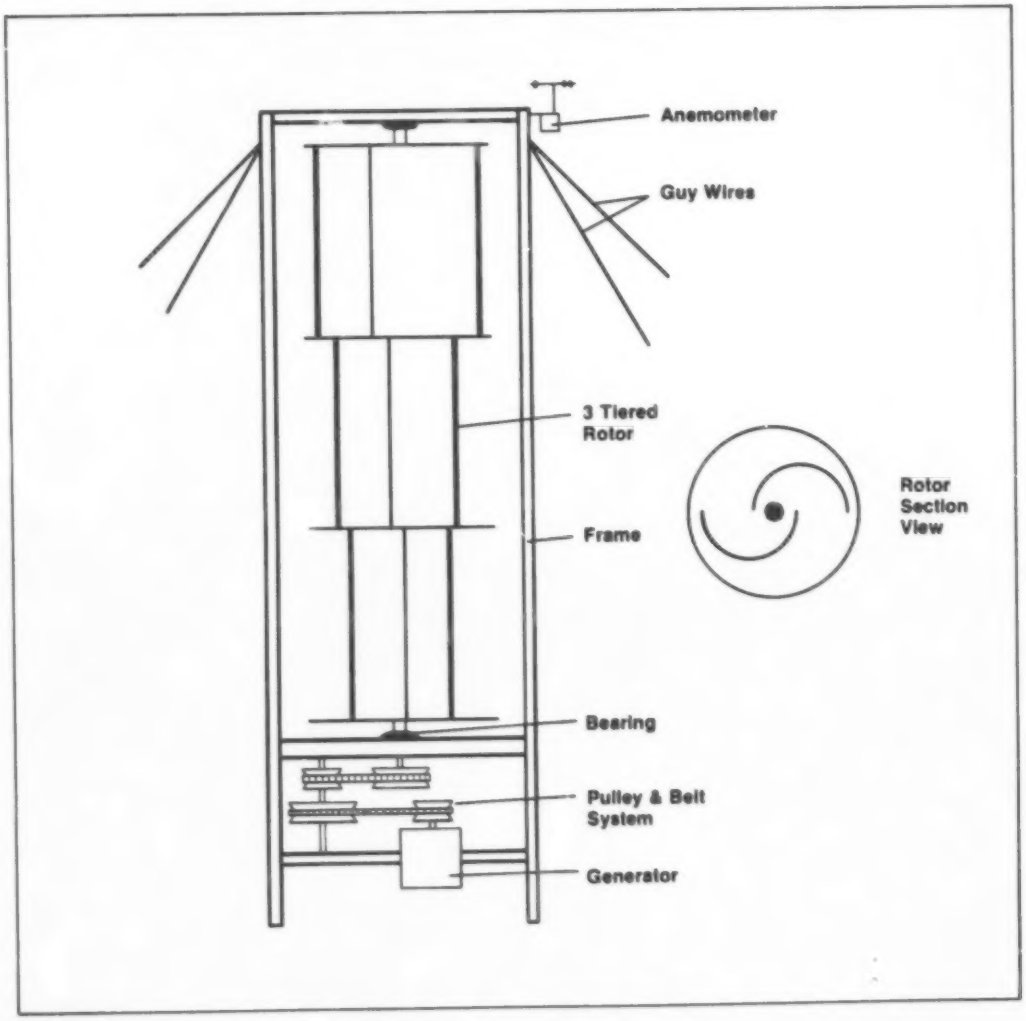
The system is more than capable of meeting the Aikens' electrical energy demand, but is costly when one considers the amount of energy produced. Mr. Aiken admits the rotor is really a hobby. As such, it produces personal satisfaction, and a previously unavailable level of luxury in the form of electricity.

Comments:

The Savonius rotor is not an efficient design for producing electrical energy. It is a safe and easy design for a hobbiest to build and experiment with. As such, it can produce a good deal of fun and a small amount of electrical energy.

Viewing Times:

Interested persons are welcome to view the rotor system. Telephone to arrange a visit—**257-2686.**



Wind Turbine

5 Kilowatt Dunlite Wind Generator

Ross Bunnell
New Germany, Lunenburg County

Purpose:

Mr. Bunnell installed a 2 kilowatt Dunlite and battery bank to generate electricity for his house, which is in a remote location. The purpose of this project is to upgrade Mr. Bunnell's original wind system by installing a 5.0 kilowatt unit. The new system will meet all the electrical needs of a house and woodworking shop and provide some energy for space heating.

Description:

While the generator was on order, Mr. Bunnell extended his free-standing 15 m (50 ft.) tower to a height of 24 m (80 ft.) by adding a 9 m (30 ft.) section of military surplus tower. He added guy wires to the combined tower, at the 15 m and 21 m (50 ft. and 70 ft.) levels.

When the 5 kw *Dunlite* unit arrived from *Solace*, Dunlite's Canadian distributor in Vancouver, Mr. Bunnell applied a fibreglass-epoxy coating to the blades. This was done in cooperation with Solace and Dunlite and may be done in future to all 5 kw Dunlites before they are erected in Canada. The coating strengthens the blades and improves their life span.

Mr. Bunnell assembled the blades and hub in his woodworking shop. He added small weights near the propeller tips to balance the assembly.

The generator, tail, and blades were then raised to the top of the tower. The entire operation was done in stages, using a gin-pole, and the help of Mr. Bunnell's friends who pulled on the ropes.

A neoprene coated, *Armaflex* cable runs from the wind generator, down the tower and into the workshop building. Inside the shop, the wires connect to the Dunlite control box and then to a switching system which permits Mr. Bunnell to use either wind generator power or back-up, gasoline generator power.

The 100 Volt, DC power from the wind generator may be stored in a battery storage system consisting of 45, 2 Volt deep-cycle batteries (note: if you are buying batteries, count them before you sign for them. Mr. Bunnell lost 10 batteries this way). Mr. Bunnell uses this power in the house and the shop for lighting but not for running woodworking tools since their motors are all AC. These tools are run directly from the gasoline generator.

Great care has been taken to protect the unit from lightning strikes. A buried, number 3 bare copper wire encircles the tower. Each leg of the tower is connected to this wire and a 3 m (10 ft.) ground rod. All wiring is grounded through this system. The primary conductors are encased in the grounded *Armaflex* wire. The control system incorporates a second surge arrestor which directs all abnormally high voltages to ground. In addition, all power wires and the field wire in the generator are protected by metal oxide variators which absorb high voltage pulses.

Performance:

The system was operational as of March, 1982. The generator exceeds its 5 kilowatt rating by producing 7 kilowatts, at feathering speed of 43 km/h (27 mph).

Mechanically, the unit seems to work perfectly, and is barely audible until the blades start to feather. If the unit were unbalanced, it would vibrate, resulting in noise. After consulting with a wind generator manufacturer in Europe, Mr. Bunnell chose to leave the guy wires on

5 kw Dunlite on 24 m Tower

the tower slack. The idea is to minimize downward loading on the tower and decrease the amount of wind-induced vibration the unit experiences. The top of the tower can move approximately 100 mm (4 in.) before the guy wires tighten.

In order to make maximum use of the electricity being generated by the wind system, Mr. Bunnell will have to increase his battery bank size and convert his power tools to DC, or install a DC-AC inverter to power the tools with their present motors. The use of excess electricity for space heating is also a future project.

The wind generator costs $9,600 and the battery bank is worth $4,500. Mr. Bunnell estimates the tower cost between $2,000 and $3,000.

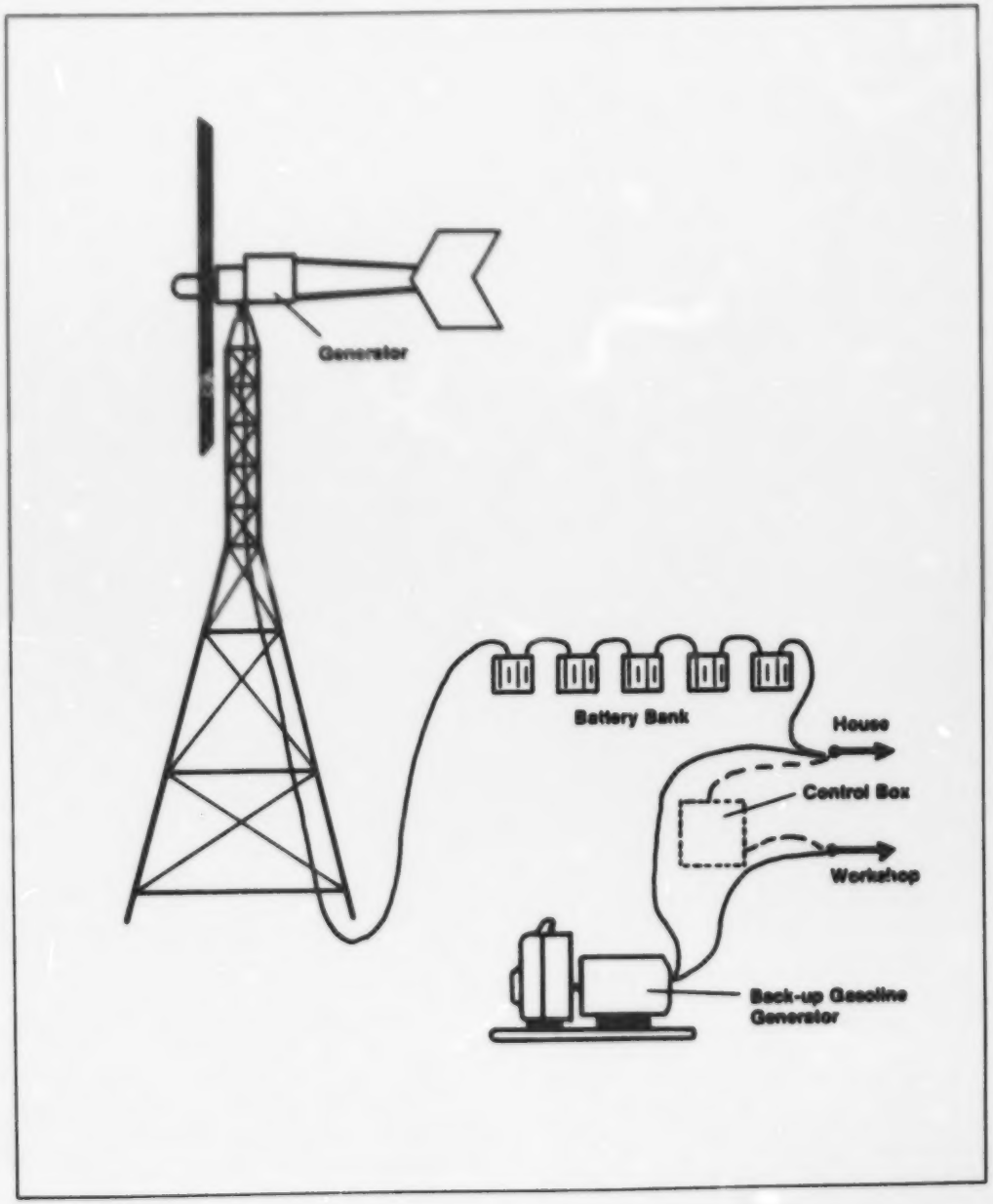
Many of the electrical and mechanical components were bought as salvage from various sources. The tower extension is part of a 24 m (80 ft.) military unit purchased for $270. The huge guy wire turnbuckles were bought for $10 each. *Armaflex* cable, worth $3/m ($10/ft.), was bought from a junk dealer for $0.13/kg ($0.30/lb.), as were most of the switches and controls.

Comments:

As a result of his knowledge and involvement in wind energy, Mr. Bunnell has been appointed as Solace's Dunlite representative in Eastern Canada.

Viewing:

Call in advance, **644-3839**, for appointment to view.



Wind Energy System

A 2 Kilowatt Whirlwind, Wind Generator System

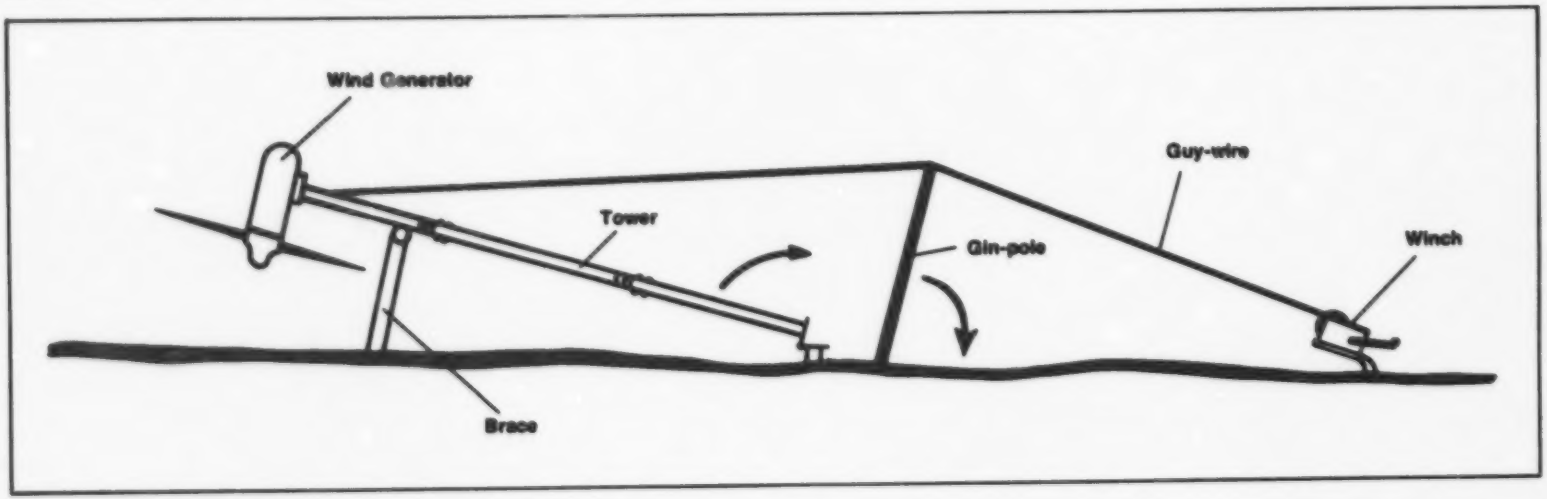
Phillip & Sally Clark
Fairmount, Antigonish County

Purpose:
The Clark residence is located beyond the Nova Scotia Power Corporation's utility lines. The wind generator system is their only source of electricity and is used for lighting and for powering small appliances.

Description:
After a great deal of investigating, searching for the elusive Canadian-made wind generator at a reasonable cost, the Clarks settled for a *"Whirlwind 2000"*, 2 kilowatt unit and a guyed, 18.75 m (60 ft.) steel pipe tower from the U.S. When the tower base arrived, it was set in concrete, according to the manufacturer's instructions. The tower consists of three 6.25 m (20 ft.) sections which bolt together, with a hinged joint at the base. A gin pole and winch were used to raise the tower from a near horizontal position to the upright position. Nine guy wires, from three concrete footings, stabilized the tower once it was erect.

Fortunately, before the Clarks raised the tower with the wind generator in place, they made several dry runs with the tower alone. They found that as soon as the tower left the ground it became very unstable. Neighbors and friends were called in to steady the tower using ropes from either side. During the second run, after the guy wire lengths were finalized, a weld at the base of the tower broke. A welder came in to repair the initial failure and check the other welds. Many had to be redone.

Generator in Lowered Position



Hoisting Mechanism for Tower

With the assistance of friends, the tower and generator were erected in the spring of 1982. Due to the extra weight of the generator, the concrete base of the tower moved. The unit was lowered, more concrete poured, allowed to cure, and the tower was erected once again.

The Whirlwind generator is a two bladed, downwind machine, that produces variable frequency AC power. Its fixed pitch, spruce blades must be visually examined and refinished once a year. A mechanical yaw system turns the unit out of the wind during high gusts of wind to protect it against damage. Dynamic braking, which uses the generator field current to slow or stop the blades, provides further protection.

A "priority" switch on the Whirlwind control box allocates the power from the wind generator. In the automatic mode, power goes to the regulated AC load, second through a rectifier to the battery load, and third to the auxiliary heater. The switch can also be set to direct power to the auxiliary heater or battery bank only.

A 2000 watt, AC space heater is supplied with the machine (it is an integral part of the dynamic braking). The Clarks hope to replace this with a water heating system. Four, eight volt *"Surrette"* deep cycle batteries form the Clarks' battery bank. A 1500 watt inverter will convert the stored DC energy to AC electricity when AC is required and the wind is not blowing.

Performance & Economics:

The Whirlwind and tower cost $6,000 Canadian. The inverter cost an additional $750 and the batteries $1500. The innumerable little expenses raised the total system cost to more than $12,000.

The Clarks do not have any wind speed monitoring equipment so they cannot determine the exact performance of the Whirlwind. Manufacturer's and Rocky Flats' data indicate the unit will produce its rated 2.0 kilowatts in 40 km/h (25 mph) wind. The Whirlwind overcomes its start-up friction in a 13 km/h (8 mph) wind.

The Clarks wired their house for both 115 volt AC and 32 volt DC using different coloured plugs to designate each. To date, the Clarks are very satisfied with their system although they have not used the AC capacity, since they do not, as yet, own any AC appliances.

Viewing:

Those persons interested in seeing the project, should call in advance to make arrangements—**883-6776.**

Dunlite 2000 Wind Generator

Terry Henderson
Baddeck, Victoria County

Purpose:
The Henderson home is located more than 2.4 km (1.5 miles) from electrical power lines. The 110 volt, DC wind generator they installed under the Small Scale Energy Demonstration Program is their only source of electricity and it was intended to supply power for lights, power tools, and household appliances.

Description:
Mr. Henderson had intended to build his own wind generator but found a damaged Dunlite unit for sale. This particular unit had been erected in a mountainous area of Cape Breton where high winds broke one of its airfoils.

Mr. Henderson bought the complete *Dunlite* system five years later, with the wind generator still on the tower. He then dismantled it, took it home, rebuilt it to original specifications, and erected it near his house. The wind generator is a 2 kilowatt Dunlite, 110 volt, direct current unit with 3 blades measuring 4.1 m (13.5 ft.) in diameter. Its cut-in speed is 12.8 km/h (8 mph) and it produces its rated 2 kilowatts at a wind speed of 40 km/h (25 mph). A centrifugal device protects the wind generator by feathering the blades at high wind speeds. The system originally had a 120 volt battery bank. However, many of the 2 volt batteries were damaged by freezing before Mr. Henderson purchased them. The battery bank is now approximately 90 volts.

The greatest problem that confronted Mr. Henderson when he was rebuilding the unit was the one broken, and two bent, aluminum airfoils. He fabricated new blades of clear spruce. The cross-section and profile of the best aluminum blade was carefully duplicated. The exterior of the new blades were covered with a polyester fabric and *"L26 Sheathing Resin"*, a resin used in marine applications. Duplicate aluminum castings were made for connecting the blades to the rotor hub. These were welded to aluminum pipes. These pipes run 300 mm (12 in.) into the end of the wooden blades. Bolts run through the blade and pipe to make a secure mechanical connection.

The wooden blades are lighter than the original metal blades. Wooden blades have very good fatigue strength and should equal or exceed the expected life of aluminum blades.

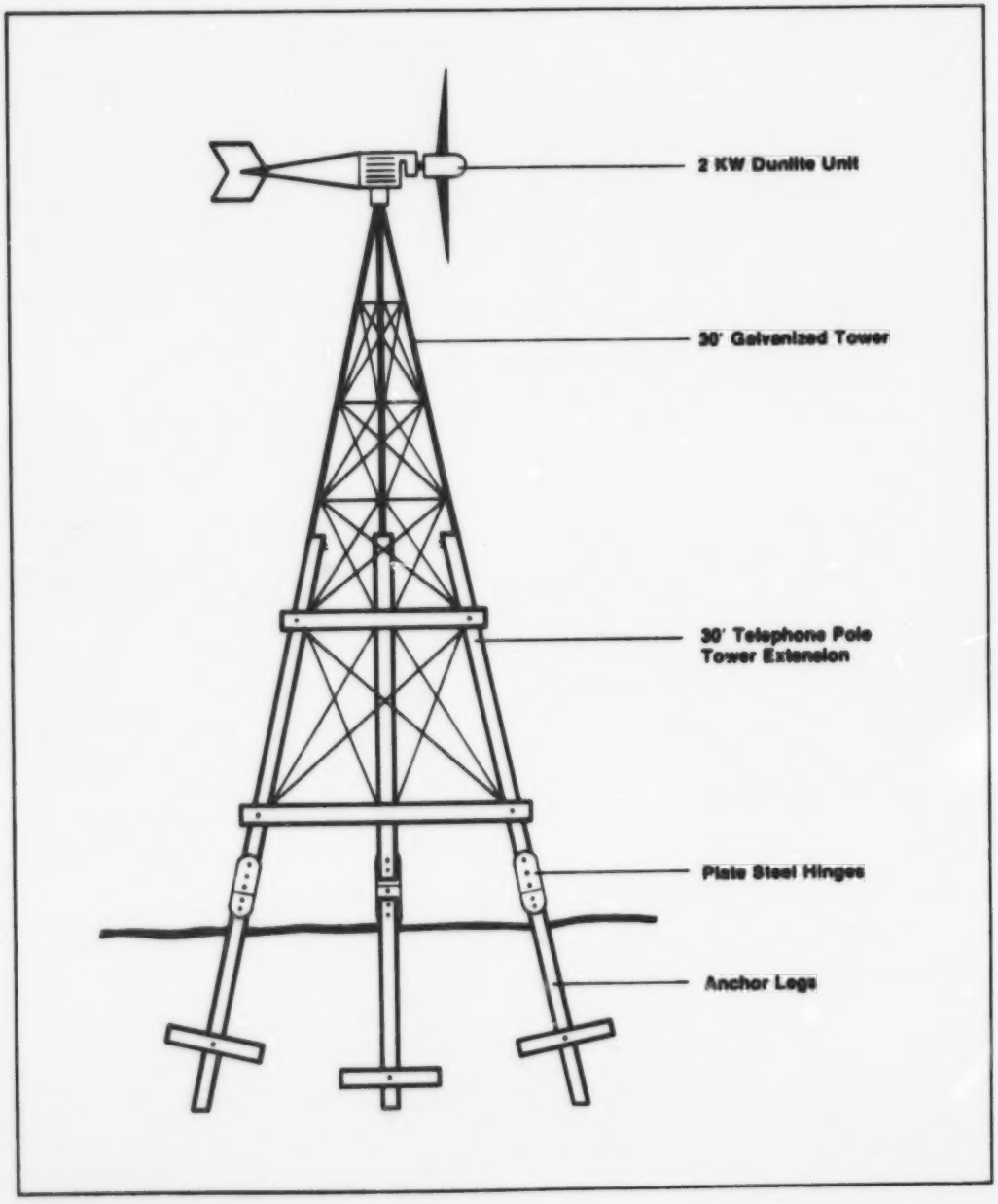
The remainder of the rebuilding consisted of freeing seized parts, cleaning and lubricating, and painting. Several worn components in the hub were replaced.

The original 9.4 m (30 ft.) free-standing galvanized tower has been extended another 9.4 m (30 ft.) by building a base tower from telephone poles. The footings for the tower consist of three vertical telephone pole sections buried 3.8 m (12 ft.) in the ground. These project approximately 0.6 m (2 ft.) above ground where heavy metal plates are bolted to them. Two of the plates act as hinges for raising the tower. The base tower was built from poles as an extension of the original steel tower. The two towers were bolted together in a horizontal position and then raised into place. A four wheel drive truck pulled the tower upright. Once in an upright position, the third leg was bolted to the third metal plate.

A block-and-tackle and a gin-pole were used to hoist the generator to the top of the tower.

The original batteries were reconditioned according to the advice of an industrial battery supplier. Of the 55 original batteries, 40 are in working order. Mr. Henderson has ordered several new batteries and will replace the original ones as funds permit.

2 kw Dunlite on Freestanding Tower



Wind Turbine and Tower

Performance & Economics:

The Hendersons had their wind generator up and operating by the fall of 1981. The generator worked beautifully. However, the battery bank did not perform up to expectations. The Hendersons currently use the electricity for lighting and plan to install an inverter to produce alternating current to run household appliances.

The generator is rated to produce 2,000 watts in a 40 km/h (25 mph) wind. At wind speeds in excess of 40 km/h, centrifugal weights trip the automatic feathering mechanism, causing the blades to turn about their axis into the wind and slow the unit's rotational speed. The system was purchased for $1,500. The same unit, new and without tower and batteries, costs approximately $5,500. Other materials and equipment cost Mr. Henderson approximately $1,800, making this system a very good buy.

Viewing:

Anyone wishing to see the system and discuss it with Mr. Henderson should phone in advance to make arrangements—**295-2726.**

Twin Wind Generator Installation

James and Sheila Livingston
Lake Charlotte, Halifax County

Purpose:

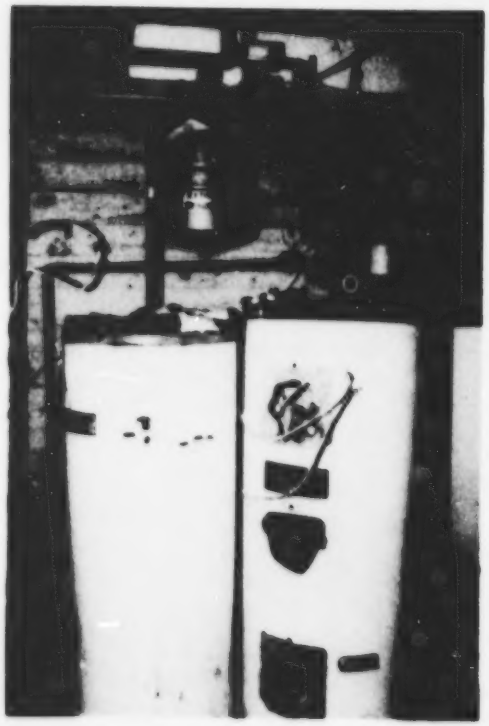
The electricity produced by two, 2 kw *Dunlite* wind generators in this project is used to heat water that is then circulated through a conventional baseboard heating system in a 98 m^2 (1,000 sq. ft.) home. When the storage water is fully heated, the electricity produced charges a battery bank, which supplies power for lighting.

Description:

After considerable investigation, the Livingstons decided to buy two, 2 kw Dunlite wind generators rather than install a single 5 kw unit. During their investigations, they found that the *Enertech* and *Dunlite* 5 kw units were not in production. When they decided to buy the *I.E.S. Skyhawk* 5 kw unit, they found that the dealer had gone out of business. The twin Dunlite system offered proven reliability at a reasonable cost.

The *Dunlites* were ordered direct from the factory in Australia, and took one month to arrive in Halifax by ship. Each unit is a 2 kw, 110 volt, direct current generator with three aluminum airfoils, 4.1 m (13.5 ft.) in diameter. They have a 12.8 km/h (8 mph) cut-in speed and reach rated output in a 40 km/h (25 mph) wind. An automatic feathering device protects the units from wind speeds in excess of 40 km (25 mph).

Twelve metre (40 ft.) telephone poles were used for towers. These were chosen because of their considerable strength and low cost. An electrical contractor was hired to erect the poles and secure each with four guy wires.



Heating System Tanks

A local machinist was hired to fabricate wind generator mounts for the top of the poles. Each mount consists of a box made of angle sections that fit over the top of the pole. Each box is bolted in place. A plate on top forms a horizontal surface to which the wind generator is bolted. The four guy wires fasten to the sides of the box. Number 4 and 2 wires are used to carry the electricity to the basement where the two electric hot water heaters are located. One heater is used for storage, while the other is used for heating. Each wind generator powers one heating element.

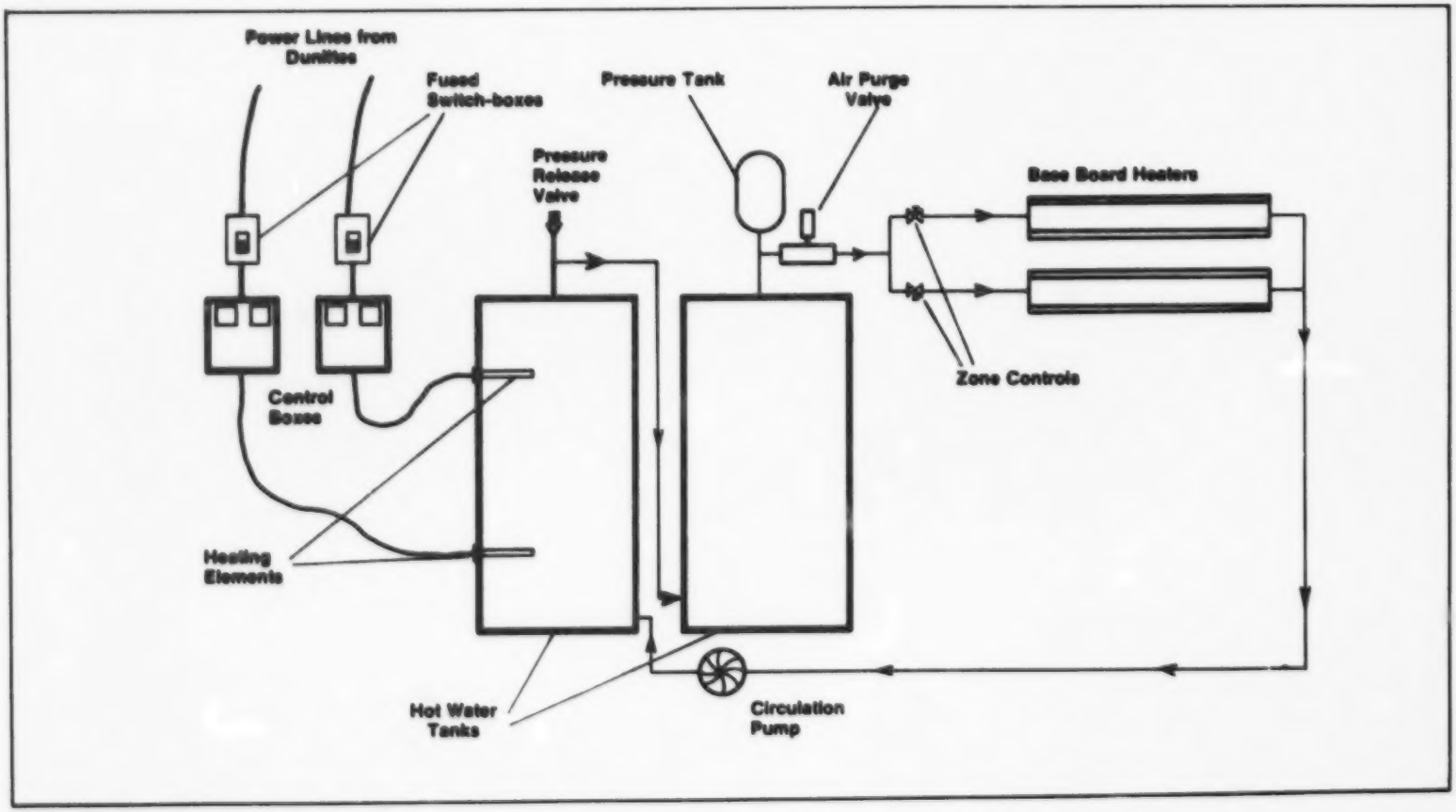
Two Dunlites on Towers

A veristor has been added to each thermostat to protect it from arcing that can occur during switching of 110 volts DC. When the water is fully heated at 83°C (180°F), electricity from the wind generators is directed to a battery bank. The Livingstons did not originally use the electricity from the batteries but do plan to use it for lighting in their new house.

Conventional thermostats operate the pump that circulates hot water through the two-zone baseboard heating when required. This hot water system is completely independent of the propane hot air furnace and wood stove heating.

Performance & Economics:

The Livingstons received $10,000 in assistance from the Small Scale Energy Demonstration Program toward the erection of these windmills as a demonstration project. The two Dunlites cost $11,000 Canadian, delivered to customs in



Wind Powered Heating System

Halifax. The poles cost about $1,500 installed. Major additional expenses include the heating system and the wire. The battery bank was purchased from the N.S. Power Corporation.

The telephone pole towers are shorter than ideal and result in a decrease in wind generator performance due to lower wind speeds near the ground. However, the Livingstons are on the shore of the Atlantic where a sturdy tower is more important than maximum efficiency. During the system's early weeks of operation, the generators easily kept the heating water hot. Some electrical switching problems occurred when the batteries tried to heat the water during periods of low wind.

The Livingstons have a rugged wind generator system capable of heating a modest, energy efficient home during most of the heating season. Their experience during the winter of 1981-82 will enable them to determine how to best use the system in the future in their new home.

Viewing:
Those persons wishing to see the project and discuss it with the Livingstons should phone in advance to make arrangements—**845-2407.**

An Alternating Current, Wind Generating System

Ron MacKay
Leitches Creek, Cape Breton County

Purpose:

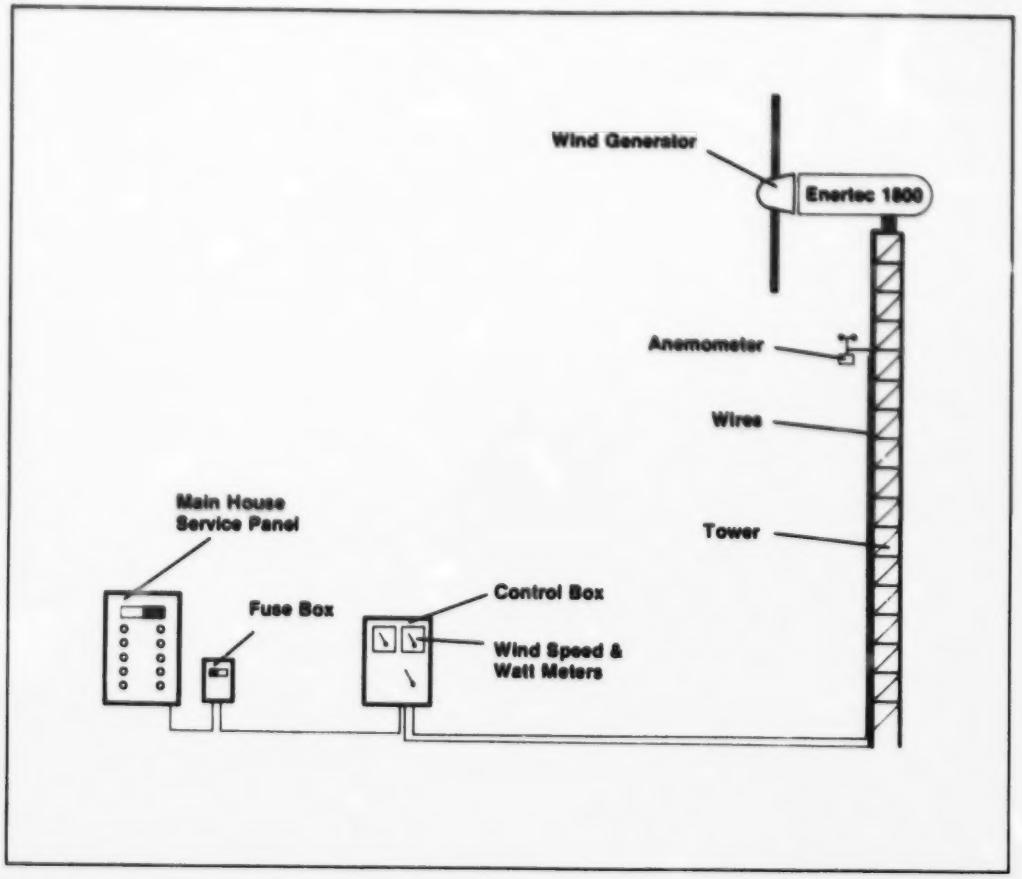
The purpose of this wind generating system is to produce supplementary electricity for a home and attached greenhouse. To accomplish this, the windmill must produce electricity compatible with that supplied by the Nova Scotia Power Corporation.

Description:

The wind generator is an *"Enertech 1800"* model, that produces 115 volt, 60 cycle, AC power, fed directly into the house's electrical system. The package came complete with a 12.5 m (40 ft.) guyed tower, control box, anemometer (part of the controls), and the wind generator itself.

The tower sits on a concrete footing and three smaller footings anchor six guy wires. A crane erected the two-piece tower, holding each section upright while a surveyor's transit ensured they were vertical. "Dynamometers" on each of the guy wires ensured equal tensioning. Once the tower was up, the crane raised the generator unit to the top of the tower where it was bolted securely in place.

A three-strand electrical wire and co-axial anemometer lead run underground between the base of the tower frame and a control box inside the house. A second, two-strand, electrical wire connects the control box to a small fuse box and then to the main fuse panel.



Wind Energy System

When the anemometer senses a wind speed of 16 km/h (10 mph) for a period of 30 seconds, the control box releases the wind generator brake and electrically drives the generator to its synchronous speed. The control box then adjusts the generator field strength and resulting output current while ensuring a constant 60 cycle per second, 115 volt electrical output during various wind speeds.

The generator brake automatically applies itself if the wind speed exceeds 64 km/h (40 mph), if the utility power is cut off, or if the wind speed decreases below 16 km/h (10 mph).

Performance:

The Enertech 1800 is rated to produce 2.0 kilowatts of electrical power at a wind speed of 38 km/h (24 mph). A watt meter in the control box monitors the generator's instantaneous output. During its first month of operation, the unit performed well except during the initial start-up, when it was discovered that a slow-blow fuse was required.

Enertech 1800 on 12.5 m Tower

Economics:

The packaged wind generator system cost Mr. MacKay $6,100 U.S., plus exchange, customs duties, federal sales tax and shipping. Mr. MacKay plans to install a watt-hour meter in the generator lines to determine the power produced.

The MacKays have an energy efficient attached greenhouse that uses electric resistance heating. They hope to build a larger, commercial type greenhouse and heat it electrically.

Viewing:

The MacKays welcome all visitors. However, they ask that interested persons telephone to make arrangements—**564-9520.**

Home-Built Savonius Rotor

Raymond MacKenzie
Big Bras d'Or, Cape Breton County

Purpose:

The ultimate goal of this wind rotor project is the generation of electricity that will help heat the MacKenzie home. The highest winds occur during the winter months when the supplemental heat is most beneficial.

Description:

Mr. MacKenzie's wind rotor is based on the split oil drum design. The rotor itself is made from three 204 L (45 gal.) oil drums split lengthwise and separated sideways. The oil drums are arranged vertically, offset from one another axially by 60°. Five mm (3/16 in.) thick steel discs were used to fasten the oil drum halves together. The whole assembly rotates around a stationary 50 mm (2 in.) steel pipe, on roller bearings mounted at each disc.

Power is transmitted from the rotor to the alternator by a 5 to 1 V-belt drive with a large home-built plywood pulley and a V-belt with replaceable links.

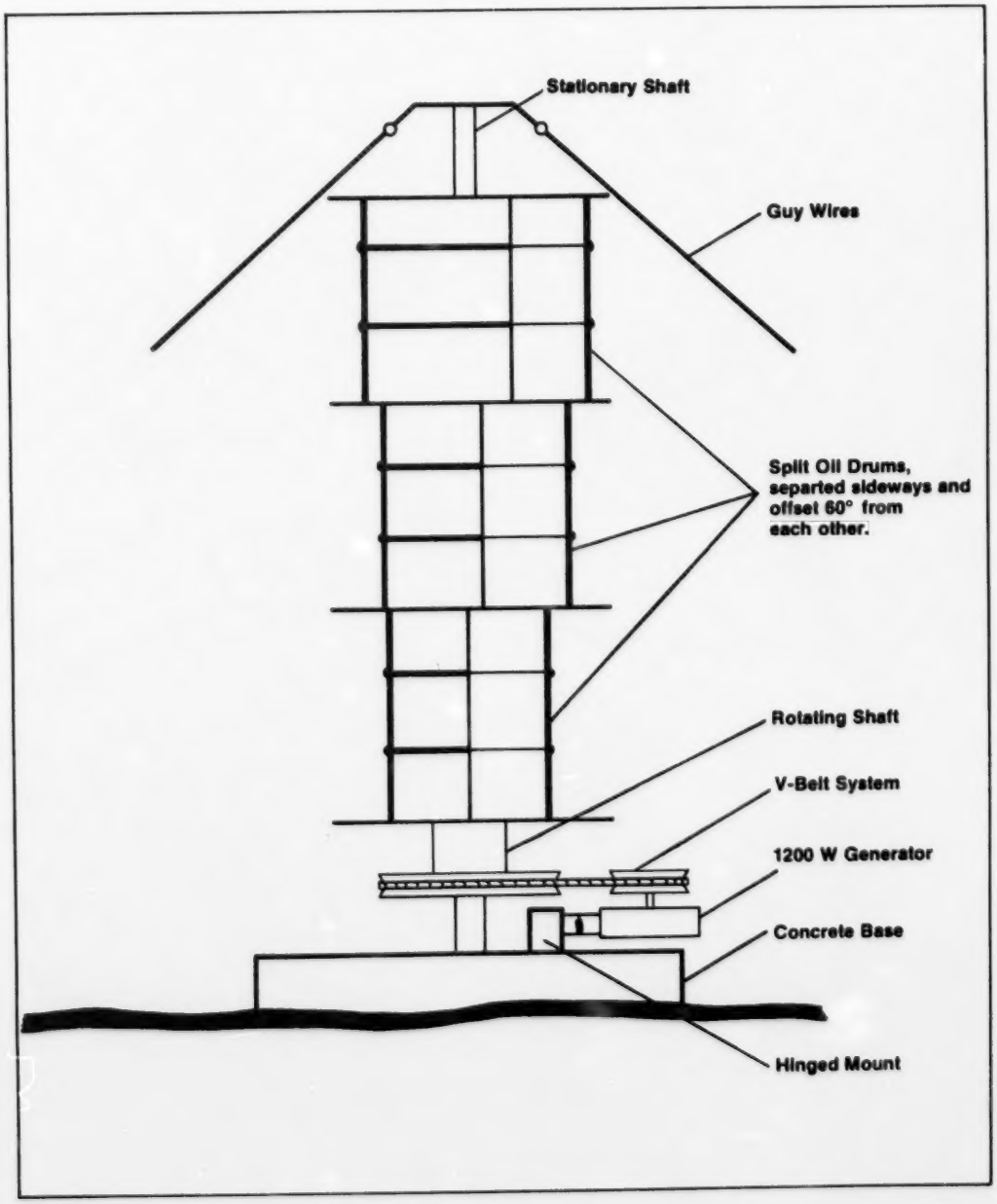
A 1200 watt, 110 volt AC, permanent magnet, *McCulloch* generator is used. This is mounted vertically on a swivelling backet which provides adjustments of the V-belt tension. Four guy wires brace the rotor, and the whole system sits directly on a poured concrete base.

Performance & Economics:

Output from the generator has been used to charge the batteries of the MacKenzie's travel trailer and to power a resistance space heater. While the electrical system does not contain any instruments for determining the power produced, the heat produced was slightly less

Close up of Generator

Wind Rotor



Wind Rotor

than normal, when the generator was connected to the 1200 watt heater, probably about 1000 watts. This was during high wind speeds. Mr. MacKenzie's wind system has no governing protection from excess wind speeds. The idea was to utilize the very high winds funnelling down the valley where the MacKenzie home is located. During its initial runs, the rotor suffered from vibrations. This balance problem has since been corrected.

The total project cost Mr. MacKenzie $1,700. At this price, the system is not valuable for the energy it produces, but rather for the satisfaction it provides.

Comments:

Any wind generator, especially a home-built unit, must be located a safe distance from occupied buildings in case of a structural or mechanical failure. During high winds when high rotational speeds are obtained, components in an unregulated system could fly off and bounce a considerable distance. Mr. MacKenzie has located the unit about 30 m (100 ft.) down a hill behind the house.

Viewing:

Anyone interested in viewing the rotor should call Mr. MacKenzie at home to make arrangements—**674-2009.**

Home-Built, 5 Kilowatt Wind Generator

Larry Oickle
New Germany, Lunenburg County

Purpose:

Mr. Oickle's goal is to produce 70 per cent of his home's electrical needs with a wind generator of his own construction. This is an admirable goal and reaching it is definitely not a project for amateurs.

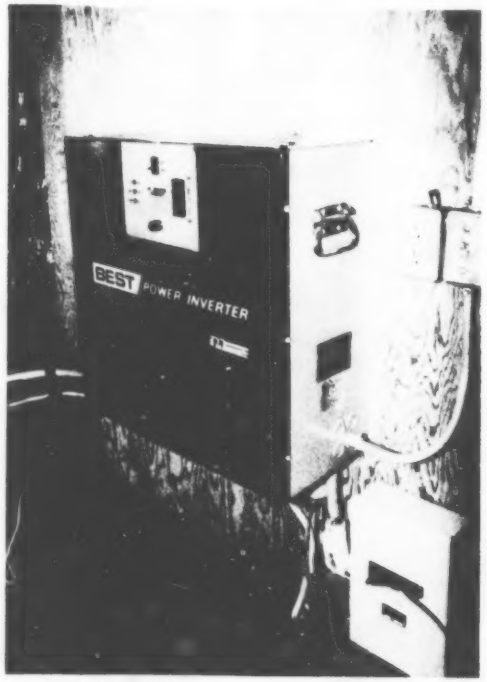
Mr. Oickle is a licensed electrician of 11 years and has considerable experience with mechanical systems.

Description:

The original intention was to build a horizontal axis wind system incorporating a 90 degree drive system at the top of the tower and a vertically-mounted generator within the tower. This design was abandoned for technical reasons and a conventional horizontal axis system, with the generator on top of the tower, was adopted.

The tower for the wind system consists of a 15 m (50 ft.) 305 mm (12 in.) schedule 40 steel pipe. This is mounted on a 6.1 m^3 (8 cu. yd.) concrete base. Ladder rungs are welded on the side of the tower and a maintenance platform is welded near the top. Four concrete footings are used to anchor the eight guy wires which secure the tower. The blades for the wind generator are exact duplicates of those found on a five kilowatt, *Dunlite* unit. These were fabricated from spruce and epoxy by local craftsman and *Dunlite* owner, Ross Bunnell.

Mr. Oickle fabricated a hub from commercially available components, which uses an adjustable spring feathering system for speed regulation.



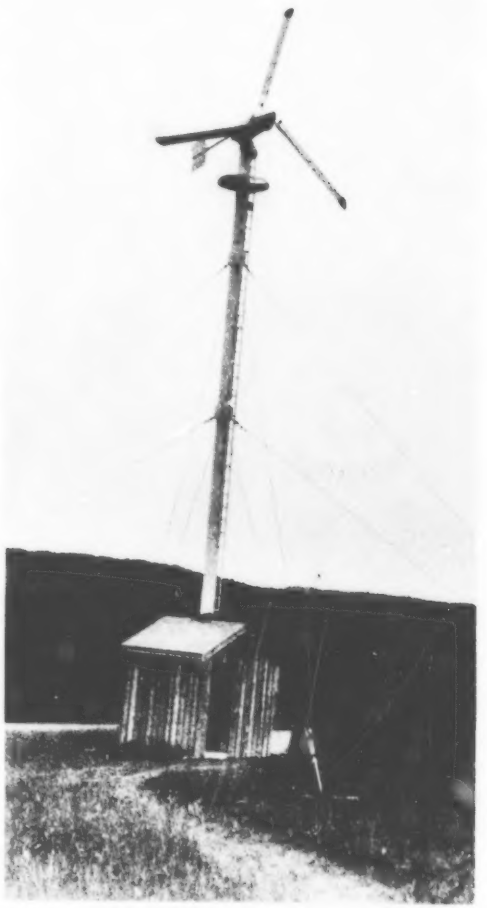
DC-AC Power Inverter

Blade pitch is not easily adjusted but can be accomplished. The blade-hub assembly was balanced on the ground before it was mounted on the generator assembly.

Power is transmitted through a 5:1 transmission, capable of handling 11 kilowatts to a 7.5 kilowatt, AC brushless generator. The electricity produced is rectified and stored as DC in the battery bank or converted to AC with a 5 kilowatt *"Best"* inverter.

The system uses the feathering hub and a swinging tail for protection from excess speeds. It also has a truck hand-brake on the transmission input shaft to hold the blade assembly stationary during maintenance.

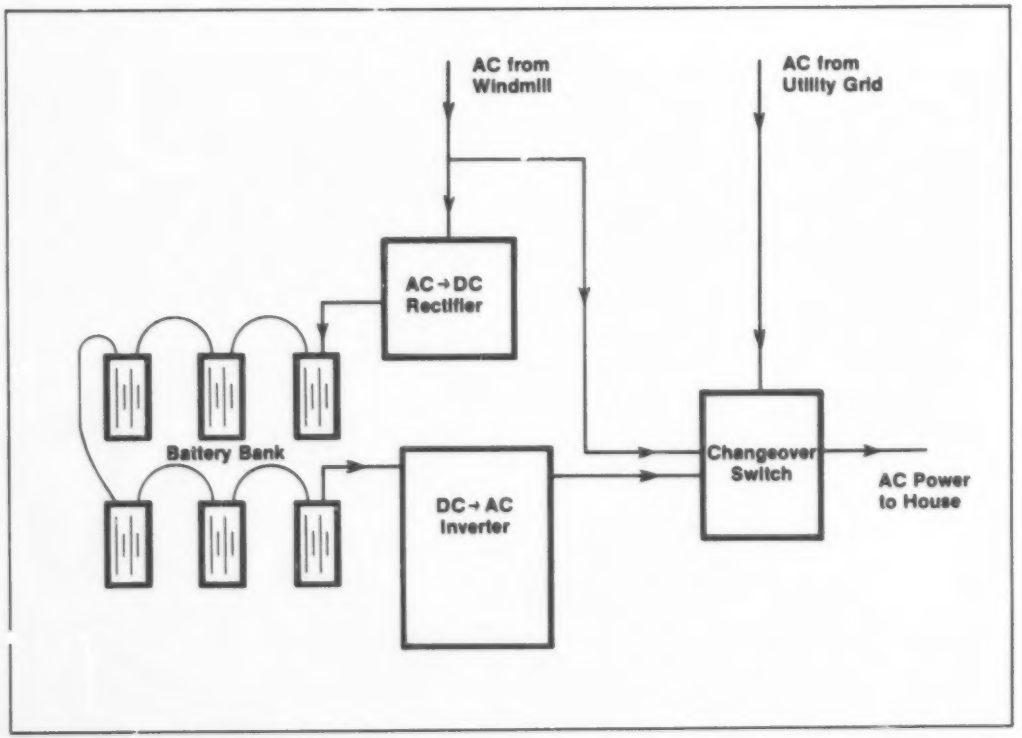
In order to avoid the use of slip rings, Mr.



Home Built 5 kw Wind Turbine

Oickle used an axial, torsion spring to keep the generator assembly from twisting the wires. Once the assembly has turned one or two full revolutions, as a result of shifting winds, it unwinds itself between gusts.

The electrical components are located in a shed which surrounds the base of the tower. The battery bank is composed of 48, 2 volt *"Gould"* batteries capable of producing 86.5 amperes for



Schematic of System

an 8-hour period. This is converted to AC by a 5 kilowatt *"Best"* inverter. Mr. Oickle has built his own battery charger and regulation system. The electrical components are protected by metal oxide veristors, which will direct high voltages (such as those induced by a lightning strike) to ground.

Performance:

Mr. Oickle's system does not include a wind speed measuring device but rather measures the rotational speed of the blades. At 80 rpm, the system produces 4.2 kilowatts. Above this speed, the blades feather, well below the 175 rpm maximum safe speed for the blades. By adjusting the pitch, Mr. Oickle hopes to produce 5.0 kilowatts.

The total system has cost just over $11,000, of which $4,000 was for the inverter alone. Mr. Oickle has contributed his personal labour, which was significant. Even so, this is a very good system for the money.

Viewing:

Please call Mr. Oickle at home to arrange a time for a visit—**644-3227.**

Innovative Heating

4

The vast majority of homes in Nova Scotia are heated by combustion or electric resistance systems. The major alternatives to conventional systems are solar heating (described in other chapters) and heat pumps.

The projects described here (with one exception) show the present range of systems based on heat pumps. They include water-to-air and air-to-air units, those designed for year-round heating and those intended to supplement existing furnaces.

Heat pumps run on electricity. They extract heat from either a water or air source and distribute it where needed. The temperature of the heat source, be it water or air, plays a critical role in determining the heat pump's efficiency.

Water-to-air heat pumps extract heat from well or lake water. Because ground water has a higher temperature than outside air during winter months, these units are the most efficient. They can provide heat year round and so do not need a costly backup heating system. However, they usually require a source of water capable of producing 22 to 45 litres per minute (5 to 10 gal./min.).

Air-to-air heat pumps extract heat from the outside air. In cold climates, they cannot operate efficiently year round and need a backup system. Their advantages are lower cost and ease of retrofit into a forced air heating system (which also serves as the backup).

The projects of Robert McCharles, Howard Turner, and Bernard McDonald have demonstrated that water-to-air heat pumps can effectively heat homes in Nova Scotia. The higher cost of the water-to-air units is offset by their superior efficiency and year-round operation.

In Mr. Turner's case, the water supply was obtained by drilling two wells, one to provide a 8°C (47°F) water supply and the second well to receive water once some heat has been removed from it. Mr. Turner removed his oil-fired, hot air furnace and replaced it with a heat pump that provides space heating, heat for domestic hot water, heat for a swimming pool, and air conditioning in the summer.

Heat pumps produce warm air at a lower temperature than a conventional forced air furnace, so more air must be delivered to maintain similar indoor temperatures. This means larger ducts are often needed. Alternately, fan speed may be increased but this often creates unacceptable drafts.

Mr. Turner undertook extensive renovations to duct work to overcome this problem, making his system an effective one.

Mr. Robert McCharles installation is basically similar, except there is no swimming pool. Mr. McCharles' calculations show that the heat pump will require 60 per cent less energy input than the old oil-fired furnace system, a net saving of $860 based on 1981 oil and electricity costs. The system was expensive, however, costing $10,000.

The Bernard McDonald project is novel in that it uses lake water rather than ground water as the heat source. Mr. McDonald was required to install new duct work because his house was equipped with an oil-fired, hot water system. (This was left intact as a backup heat source.) Because wells were not required, using lake water proved less expensive than using ground water. However, water temperatures reach levels (3°C in February) below that of ground water, thereby reducing the efficiency of the system.

The efficiency of air-to-air heat pumps goes down as the outside air temperature drops. Air-to-air heat pumps are efficient when the outside air temperatures are above -8°C (17°F). Below a certain temperature, conventional heating systems are usually more efficient. This temperature is determined by the model of heat pump used and the home in which it is located.

Four air-to-air heat pump projects described here (Mr. Boymook's, Mr. Coolen's, Mr. Dumaresq's, and Mr. Wilmot's) are twinned with oil-fired, hot air furnaces. In each case, a heat exchanger coil in the hot air plenum or ducting heats the air prior to circulation through the dwelling.

A thermostat controls the system by preventing heat pump operation below a preset outside air temperature (usually -8°C or 17°F) and preventing furnace operation above this temperature. This allows both the heat pump and the furnace to operate in conditions under which each can perform more efficiently.

An insulation upgrade of a house with an older oil-furnace can leave the heating system oversized and very inefficient. Adding a heat

pump in such a case could increase furnace inefficiency even further.

Before installing a heat pump, it is recommended that a qualified engineer or technician check duct sizes, furnace burner nozzle size and furnace condition.

When heat pumps are used in this way, oil consumption generally declines dramatically, but overall energy costs decline less because of increased electricity use. Estimates of return on investment periods for add-on heat pumps vary from four to eight years.

Energy savings will be substantially less for add-on air-to-air units when compared with water-to-air year-round units, but capital costs are in the $3,000 range, significantly below water-to-air units.

The final project described in this section is solar related. It uses solar collectors to provide space heat for a home.

The use of zeolites as a heat storage material gives Frederick Wendt's project true seasonal heat storage capability. Common thermal mass materials such as water and rock can only provide short-term thermal storage while the sun's energy can be stored indefinitely in dry zeolites. Technical problems were encountered in obtaining sufficiently high temperatures for drying the zeolites to store solar energy and then in uniformly moistening them to release the stored energy. Mr. Wendt's work proved the feasibility of this seasonal storage while identifying some of the practical limitations.

Add-On Heat Pump

V. Boymook
Dartmouth, Halifax County

Purpose:

This project demonstrates the economics of using an air-to-air heat pump in conjunction with an oil-fired, hot air furnace. Each unit will be operated during weather conditions suited to its optimum performance.

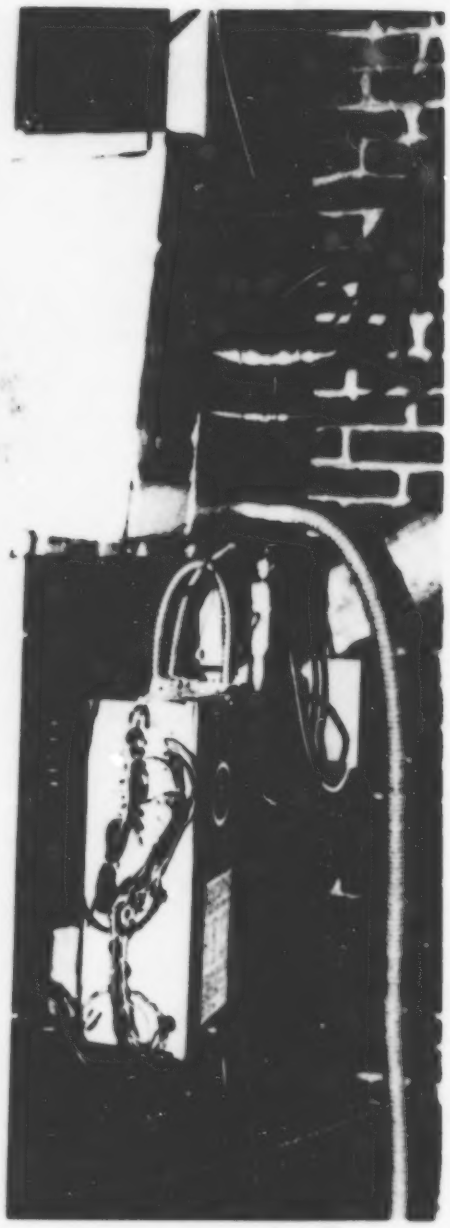
Description:

The *York Maximiser, CHP 24,* heat pump consists of three components. A compressor, fan, and heat exchanger unit sits outside the house on an elevated concrete base. A heat exchange coil and control module are located in the hot air return and on the side of the oil furnace, respectively. A new wall thermostat in the house regulates heating and cooling.

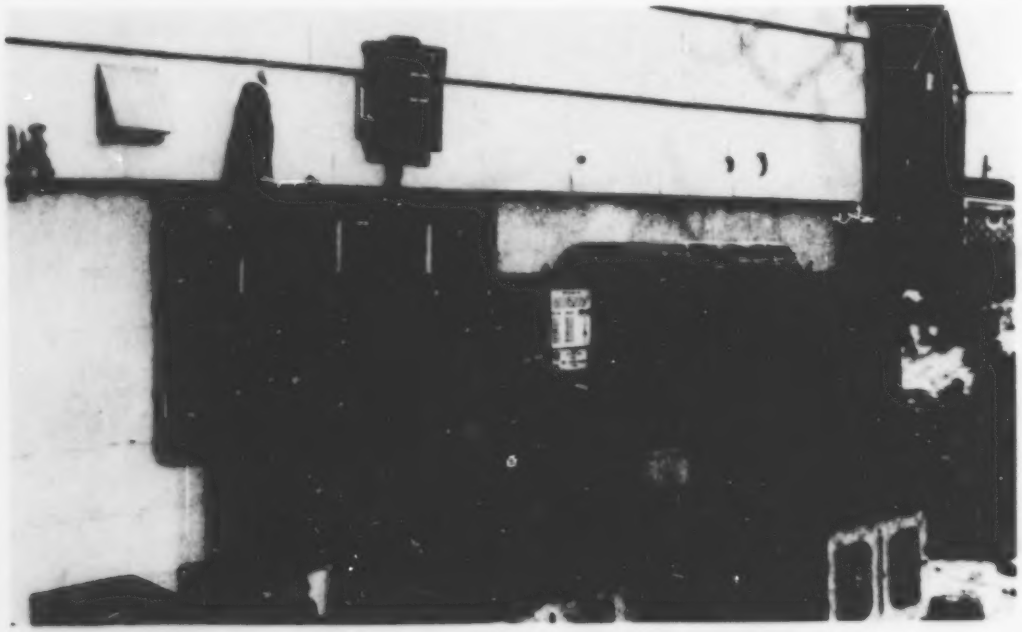
Air-to-air heat pumps operate very efficiently when outside air temperatures are above freezing. In the spring and fall, the heat pump can meet all of the home's heating needs. As the temperature drops, the heat pump becomes less efficient until at about -12°C (10°F); its efficiency equals that of electric resistance heating.

The opposite occurs with an oil-fired furnace. Furnaces are least efficient when they run for short periods, as happens during the spring and fall. During the coldest part of the winter, a properly sized, efficient furnace will run almost constantly and, therefore, very efficiently.

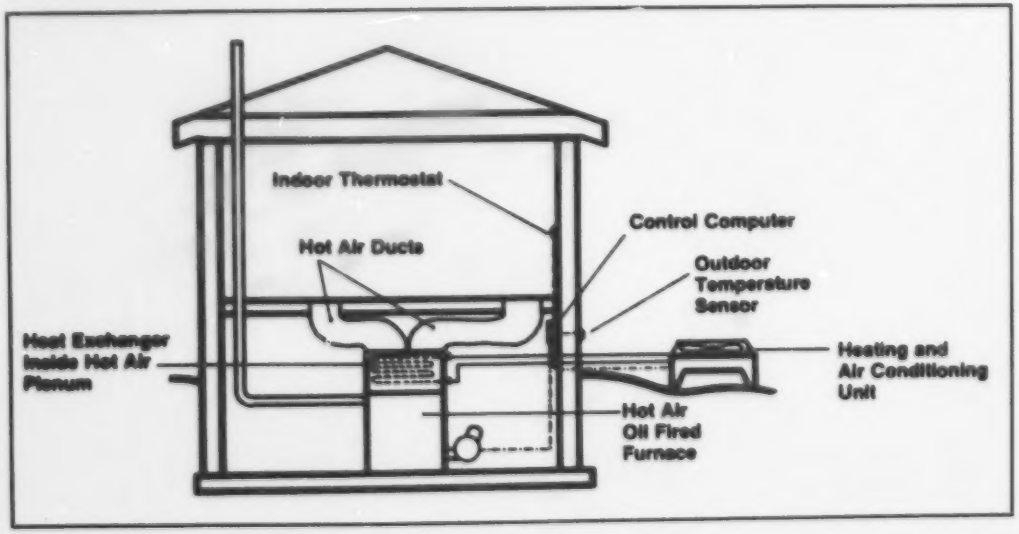
The control module in the *York* system determines when to operate the heat pump according to three factors: the actual indoor temperature, the temperature called for by the wall thermostat, and the outdoor temperature. In Mr. Boymook's situation, the heat pump



Heat exchange coil (above) and controls (below)



Outdoor heat pump unit



Heat Pump/Furnace Combination

will handle all the heating needs until the outdoor temperature drops below -8°C (18°F). If the outdoor temperature drops below -12°C (10°F), the heat pump shuts off and the oil furnace takes over. In between -8°C and -12°C (0°F and 10°F), the heat pump runs constantly and the furnace comes on periodically.

Performance & Economics:

The consultant who prepared Mr. Boymook's proposal to the Small Scale Energy Demonstration Program calculated that the add-on heat pump will reduce Mr. Boymook's energy bills by 52 per cent. Based on 1981 fuel oil and electricity costs, the $2,600 installation will pay for itself in ten years. The payback period is often shorter for poorer insulated homes.

Members of the Boymook family have complained that the air coming from the registers is cool. Heat pumps do not produce air as hot as that of a furnace. To distribute the same amount of heat, the air must be moved more quickly, as a result, air leaving the registers often feels cool.

Viewing:

Persons wishing to see the heat pump installation should phone Mr. Boymook at home to make arrangements—**469-3204.**

Add-On Heat Pump

Paul Coolen
Enfield, Hants County

Purpose:

The project will test whether an average home with a typical oil-fired, hot air heating system can benefit from the installation of a small, add-on heat pump. It was estimated that the project will reduce heating costs from $1,160 per year to less than $600 per year (1981 costs).

The project will attempt to show that both the first cost and the payback period for an add-on system are reasonable.

Description:

The Coolen's 168 m^2 (1,810 sq. ft.), 25 year old house has insulation levels of RSI 2.1 (R-12) in the walls, RSI 3.5 (R-20) in the roof, and RSI 1.2 (R-6) in the basement. The house was heated entirely by a well maintained, oil-fired, hot air furnace.

A *"York Maximiser Add-On Heat Pump"* rated at 30,000 BTU/hr, 8°C (47°F) outdoor air was added to the existing heating system. The compressor and evaporator coil (in the heating mode) were placed outside the house on concrete blocks in an area protected from snow. Two copper tubes and an electrical wire run from the outdoor unit, through the house wall at the floor joists, and into the basement to the hot air furnace. The condenser coil (during the heating mode) was installed inside the hot air plenum of the furnace. The control module was mounted on the side of the furnace and is connected to the outdoor unit, furnace and the thermostat.

Air-to-air heat pumps can be considerably more efficient than conventional resistance electric heat, but their efficiency decreases as the heat source temperature (outdoor air temperature) decreases. This particular combination makes the best use of both systems, requiring about one-third to one-half less energy to heat a house over a full year.

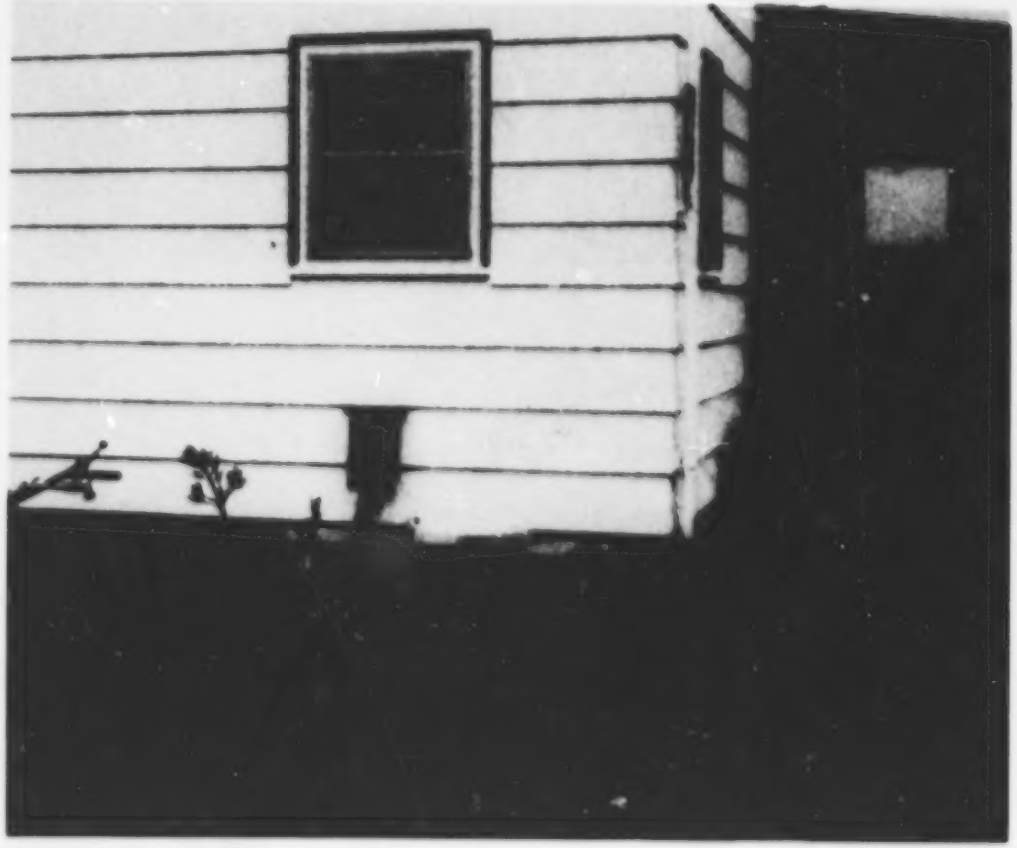
In Mr. Coolen's case, the heat pump is capable of heating the house until the outdoor air temperature drops to about -3°C (26°F). Below this temperature, the heat pump and oil furnace operate together. Below -12°C (10°F) the heat pump shuts off and the furnace takes over.

Performance & Economics:

Nova Energy, Mr. Coolen's consultant, estimates the heat pump will reduce the total heating bill by 49 per cent based on 1981 oil and electricity costs. Mr. Coolen paid $3,585 for equipment and installation.

Viewing:

Telephone **883-2751** to make arrangements for viewing.



Heat Pump on Concrete Pad

Add-On Heat Pump

Peter Dumaresq
Dartmouth, Halifax County

Purpose:

Adding an air-to-air heat pump is expected to cut the Dumaresqs' energy consumption by increasing the overall efficiency of the Dumaresqs' home heating system.

Description:

Mr. Dumaresq hired a consultant, Nova Energy Limited of Dartmouth, to analyse his present home heating system and assess the feasibility of adding an air-to-air heat pump to the existing oil-fired hot air furnace. They determined that a *York Maximiser, CHP 24* unit, could reduce Mr. Dumaresq's energy bill by 51 per cent (based on 1981 electricity and fuel oil prices).

The outdoor components were set on concrete blocks in an area protected from snow. Indoors, a heat exchange coil was installed in the hot air plenum of the furnace and a control panel was fastened to the side of the furnace. Two copper pipes and a wire connect the three components. The thermostat was replaced with a new unit which controls all heating and cooling functions.

The heat pump will meet the home's heating needs until the outdoor air temperature reaches -6°C (21°F). Between -6°C and -12°C (21°F and 10°F), the oil furnace cycles and the heat pump runs continuously whenever the wall thermostat senses a room temperature below the indoor temperature setting. Below -12°C (10°F), the oil furnace operates in the conventional manner.

The control box on the furnace initiates both units on and off. It also determines when to reverse the heat pump to defrost the evaporator coil.

Heat Pump on Wooden Pad

Heat Pump Components attached to Furnace

Performance & Economics:

Problems with the control module delayed completion of the project. When this unit was replaced, the unit operated perfectly. However, the Dumaresqs missed most of the 1982 heating season, making energy savings impossible to calculate for that year. Mr. Dumaresqs paid $3,149 for equipment and installation.

Viewing:

To view the installation, telephone Mr. Peter Dumaresq at home to make arrangements—**463-2106.**

Ground Water Source Heat Pump

Robert McCharles
Coxheath, Cape Breton County

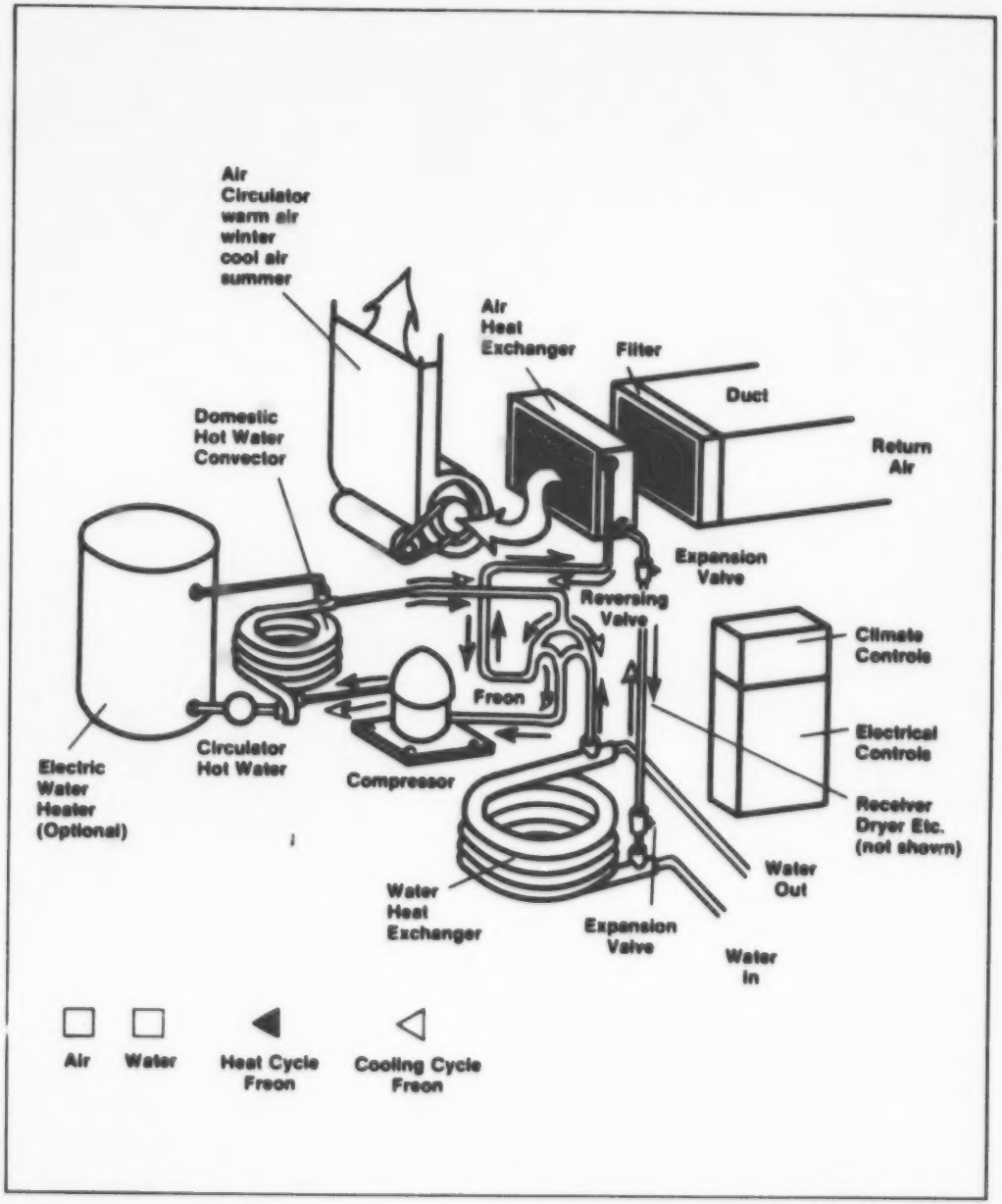
Purpose:
Mr. McCharles's project retrofits an existing residence with a ground water source heat pump. This replaces his oil-fired furnace with a more efficient system. The heat pump system demonstrates the use of ground water as a renewable energy source for total residential heating.

Description:
Mr. McCharles's domestic water supply well was monitored for 2 1/2 years and is capable of producing more that 113.5 L (30 USG) per min. at a temperature of 8°C (48°F). This is more than sufficient for a heat pump as it requires 30 L (8 USG) per min.

A return, or recharge well, was drilled to accept the discharged water from the heat pump. This well must penetrate a different aquafier than the supply well or the water source will "shortcircuit", causing continuous extraction of heat from the same water until it cools to a point where the heat pump cannot operate.

A *Wescorp, EC 39-02* heat pump with optional domestic water heater was installed. Since the existing system was baseboard heating, hot air ducts also had to be installed. These were insulated with a foil-backed rigid fibreglass material.

A water flow meter and a kilowatt-hour meter were installed so that Mr. McCharles could monitor the heat pump's performance.



Groundwater Source System

Heat Pump with Panel Removed

A special electric hot water heater with additional plumbing connections is tied into the heat pump. The electric elements in the heater only operate when the heat pump is off and the water temperature drops below the set temperature. This ensures the heat pump will not run solely to heat water.

Performance & Economics:

The total unit and installation have cost about $10,000. The cost would have been higher if a suitable supply well had been drilled.

Mr. McCharles' calculations show that the heat pump will use 60 per cent less energy input than the old oil-fired system. (The house still requires the same amount of energy, but the difference is supplied by extracting heat from the well water.) Using 1981 electricity and oil costs, this amounts to an $860 annual saving, resulting in a payback period of about 12 years.

Viewing:

To view the project, persons should telephone Mr. McCharles to make arrangements—**839-7538.**

Lake Water Source Heat Pump

Bernard McDonald
Waverley, Halifax County

Purpose:
This heat pump project demonstrates the feasibility of using lake water as a heat source.

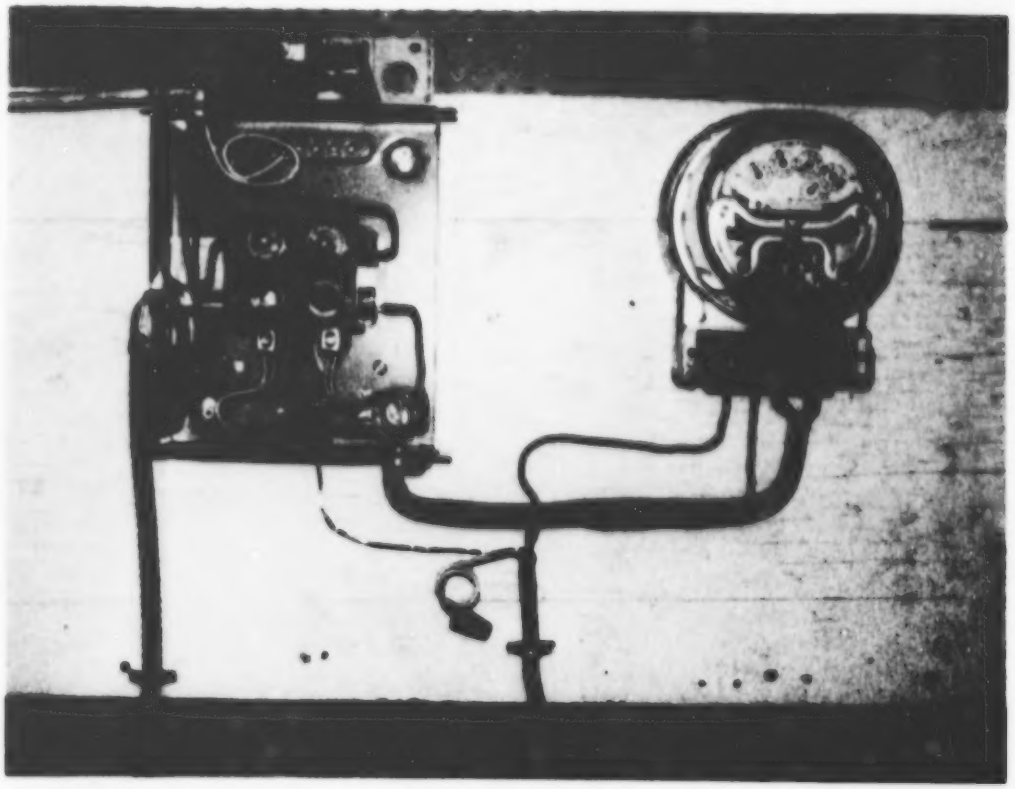
Description:
The McDonalds' 186 m^2 (2,000 sq. ft.) bungalow was built to electric heating insulation standards in the late 60s, and heated by an oil-fired hot water system.

A *"York, Triton"* water source heat pump, rated at 7,180 w. with 7°C water source (24,500 BTU/hr with 44°F) was installed as a completely separate system from the oil furnace. The original system remains as a back-up to the heat pump.

Hot air heating ducts were installed to distribute the hot air from the heat pump. Fortunately, the basement has a high ceiling with only one finished room, making installation of the duct work straightforward.

The heat pump uses lake water, extracted from a depth of 10.7 m (35 ft.). Water is supplied through 38 mm (1 1/2 in.) inside diameter plastic pipe and by a 560 W (3/4 HP) centrifugal pump. The pipe is buried below the frost level between the house and the lake. The output side of the heat pump empties into a small brook beside the house.

Performance:
During the fall and winter of 1982, Mr. McDonald used a thermocouple to measure the temperature of the lake water at various depths and distances from shore. The lowest temperature he recorded was 3°C (37°F) in late February. He also noted that temperatures did not vary considerably with depth, perhaps due to currents.



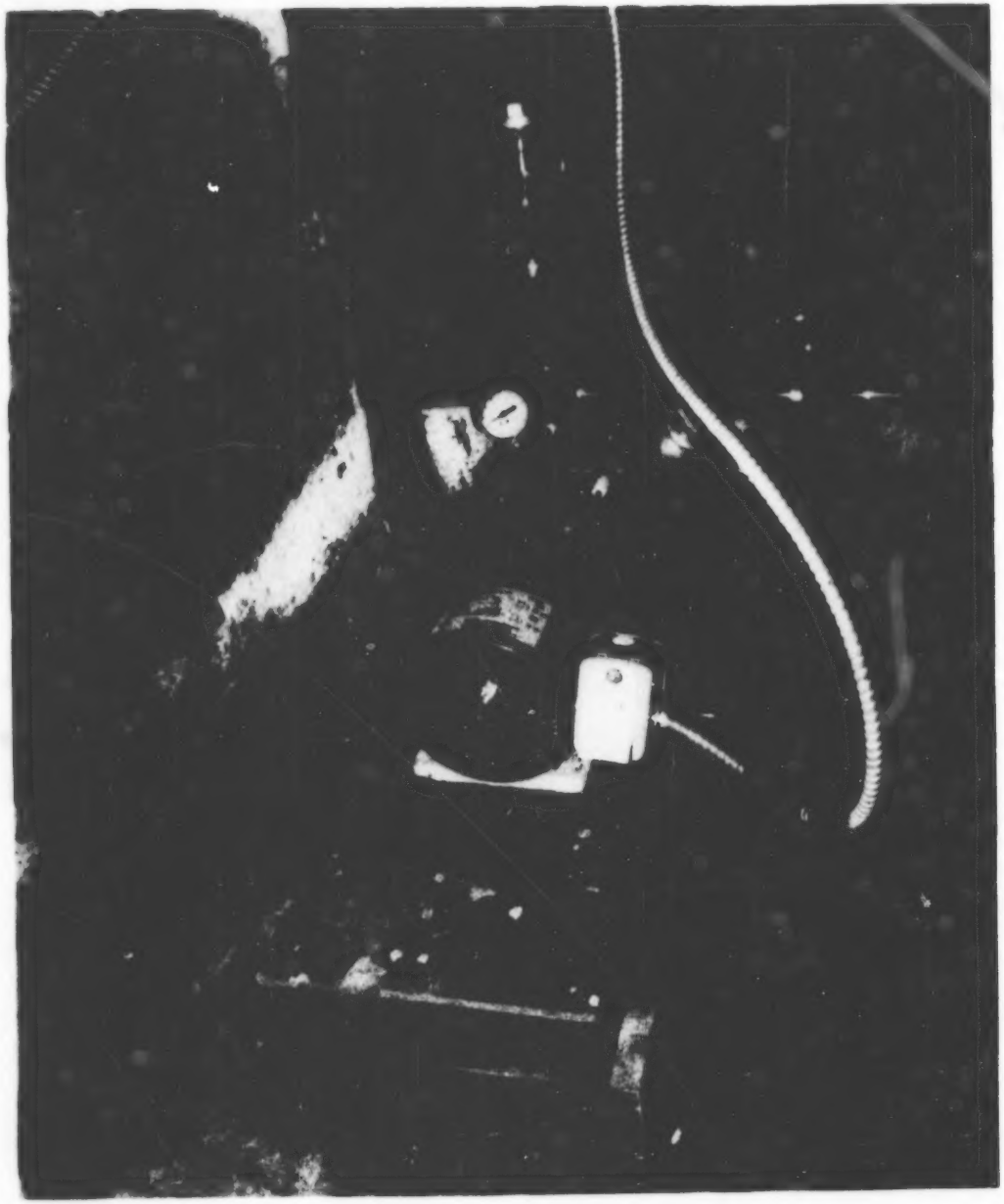
Kilowatt meter (left) and fuse box

A kilowatt-hour meter in the supply line to the heat pump enables Mr. McDonald to determine how much energy the heat pump uses. While it does not include the energy used by the water pump, it does provide a reasonably accurate measure of the electrical energy used for heating for comparison with historical oil consumption.

The consultant who designed this system for Mr. McDonald claims the heat pump will reduce the total heating bill by 51 per cent (using 1981 electricity and oil costs).

The total system cost $4,720 of which the heat pump itself cost $2,700.

Comments:
Before a heat pump that uses lake water as a source is installed, water temperatures at various depths and locations should be monitored for at least one winter. These data can help a competent designer evaluate a heat pump installation.



Pump for water circulation

Colder water requires higher flows if the same amount of heat is to be extracted. If the inlet water is within a few degrees of freezing (the actual temperature depends on the unit), the heat pump's protective circuitry will shut the unit off to prevent freezing.

Viewing:

To make arrangements telephone—**861-2467.**

Ground Water Source Heat Pump

Howard Turner
Auburn, Kings County

Purpose:

Mr. Turner chose a ground water source heat pump as an energy efficient method of heating and cooling his home, of preheating domestic hot water, and of heating a swimming pool. The heat pump is the only heating system capable of meeting all these needs.

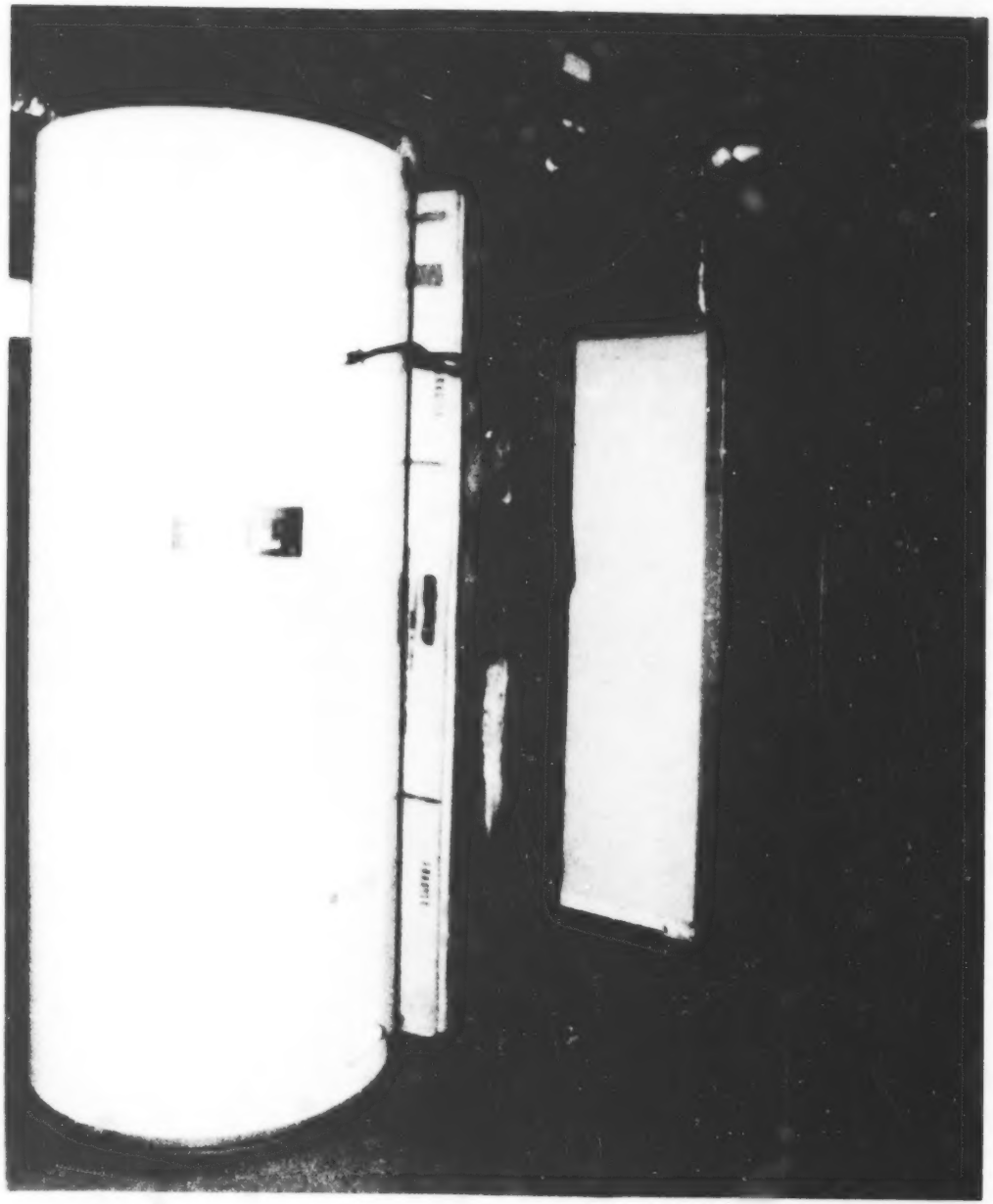
Description:

The Turners live in a large, old rural home heated by an oil-fired furnace. Their hot water has been supplied by an electric heater and the pool has been heated with solar absorption blankets.

The heat pump Mr. Turner chose is a *Wescorp EC 39-01* rated at 39,000 BTU/hr. in the heating mode and 30,000 BTU/hr. in the cooling mode. At the specified heat rating, the unit will require 26.3 L/min. (6.8 gal./min.) of 10°C (50°F) water. Ground water in Nova Scotia is about 8°-11°C (47°-52°F).

Two wells were drilled, one for supply and the other for return. Both have a 152 mm (6 in.) casing. The supply well is 50 m (165 ft.) deep and produces 155 L/min. (40 gal./min.) at a temperature of 8°C (48°F). The water is supplied by a submersible pump in the supply well. The return well is 53.4 m (175 ft.) deep.

The original oil-fired hot air furnace was removed and the heat pump installed in its place. Extensive renovations increased the size of existing ducts; where possible they were insulated.



Hot Water Heater and Heat Pump (rear)

The heat pump unit chosen has a hot water heating option whereby domestic water in a 270 L (60 gal.) tank is preheated in the heat pump. The tank has an electric back-up which heats the water when the heat pump is not operating. This ensures that the heat pump doesn't operate just to heat water.

Pipe work and valves were installed between the pool circulation system and the heat pump to enable the pool to be heated as the heat pump cools the house in summer.

Performance:

In the heating mode, the system works well. It seems that the duct work modifications improved the air flow to some of the traditionally cooler rooms upstairs.

Viewing:

Telephone **427-9281** to arrange to view the project.

Zeolite Heat Storage for Residential Solar Heating

Frederick Wendt
Ellershouse, Hants County

Purpose:

Mr. Wendt intends to use zeolites as a long-term heat storage medium. Due to the properties of zeolites, summer solar energy could be stored for use in winter when heat is required but sunshine is less plentiful. Zeolites are rocks made from clays containing aluminum and silica.

Description:

When dry zeolites are allowed to absorb moisture, they give off heat. Mr. Wendt's solar system dries zeolites during the summer, the dry particles are then placed in airtight containers and stored until winter. When heat is required, the zeolites are moistened by passing damp air through the matrix. As the moisture is absorbed, the zeolites give off their heat to the moving air stream.

Mr. Wendt planned to build his own hot air solar collector but soon found that conventional flat plate collectors could not produce sufficiently high temperatures to dry zeolites (150+°C, 300+°F). He built a parabolic collector using a plywood frame and an aluminized mylar film. This produced a temperature of 182°C (360°F) before the acrylic tube, mounted at the focal point, melted.

Mr. Wendt continued working with this collector (now fitted with a *pyrex* tube) but found an automatic tracking system was required. The parabolic collector has been replaced by two evacuated tube collectors with a selective absorbtive coating. These units are capable of reaching 175°C (347°F) stagnation temperature.

Drying Chamber

The collectors, placed inside an attached greenhouse, achieved a temperature of 138°C (280°F) by April. Higher temperatures are expected during summer.

An old refrigerator houses the zeolites, which are dried in wooden boxes with screen bottoms. The dried zeolites are kept in sealed 23 L (5 gal.) cans.

A variable speed fan draws warm air from the peak of the greenhouse and forces it through the two collectors. From there, the air flows to the refrigerator and up through the zeolites. After passing through the box of zeolites and picking up moisture, the air is exhausted.

During the heating mode, moist air is blown through the zeolite and the warmed air is directed to the living space where heat is required. Initially, a heating system humidifier provided moist air, but this proved ineffective. In future, an oil burner nozzle and pump will be used to provide a fine mist.

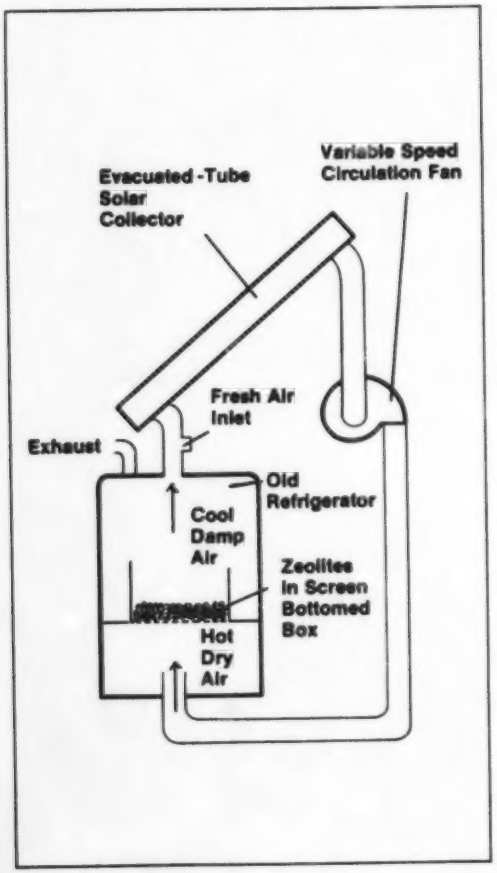
Performance & Economics:

Mr. Wendt's initial investigations showed that zeolites are able to store 450 K cal/kg°C (450 BTU/lb.°F). His calculations showed that a 680 kg (1,500 lb.) supply of zeolites would be capable of meeting his home's seasonal heating needs.

The cost of the evacuated tube Amherst solar collectors, was $1,100.00. Zeolites turned out to be prohibitively expensive at from $8.80 to $13.20/kg ($4.00 to $6.00/lb.). This means the seasonal supply would cost $6,000 to $9,000, depending on the type of zeolite used. Non-synthetic, native zeolites were tried but found to be much less efficient. Following is a table listing the heat storage properties of the various zeolites Mr. Wendt investigated.

Viewing:

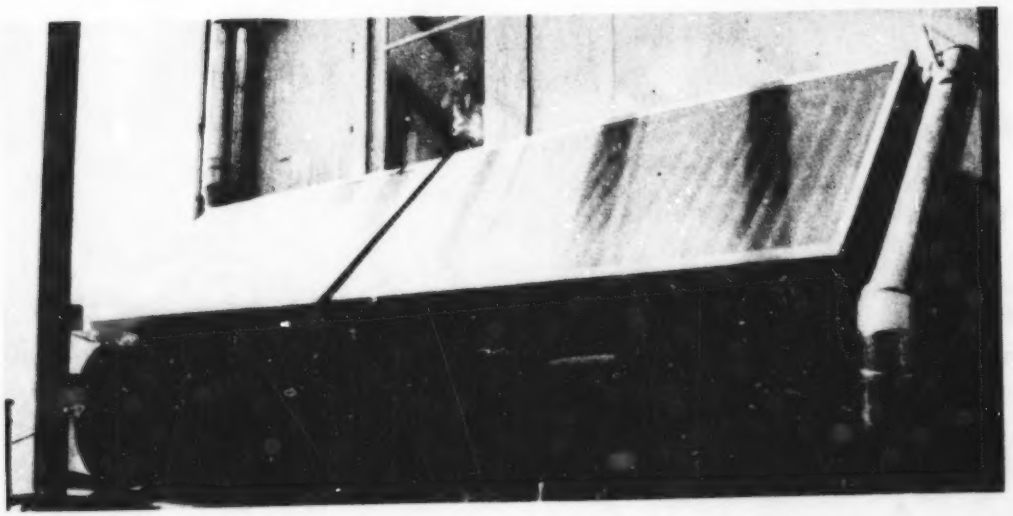
Persons interested in seeing this project and discussing it with Mr. Wendt should telephone to make arrangements—**757-2085.**



Zeolite System Schematic

TABLE

Zeolite	Weight g	Drying Temp. °C	Time Hr.	Loss of Chem. Water, g	Water Added g	Temp. gain °C	Energy gain kj/kg
Chabazite	50	175	0.1	6.5	16.5	36.7	50.0
Heulandite coarse	50	120	0.16	6.0	16.0	5.6	7.6
Heulandite fine	50	150	0.16	4.5	16.0	7.8	10.0
Natrolite	37	150	0.16	3.0	15.0	8.9	15.0
Stilbite	50	150	3.0		100.0	14.4	120.0
Chabazite	50	100	0.6	5.0			
same specimen		150	0.9	2.0			
Continuing drying		200	1.6	0	100.0	11.1	100.0



Solar Collectors

Heat Pump Addition to a Hot Air Furnace

Frank Wilmot
Windsor Forks, Hants County

Purpose:

This project will demonstrate that an air-to-air heat pump supplementing an existing oil-fired, hot air furnace can lower the total energy consumption by increasing the efficiency of the overall heating system.

Heat pumps are most efficient when the difference between inside and outside temperature is small. Therefore, the heat pump will not be operated when the outdoor air temperature is below -4°C (25°F); only the hot air furnace will be used.

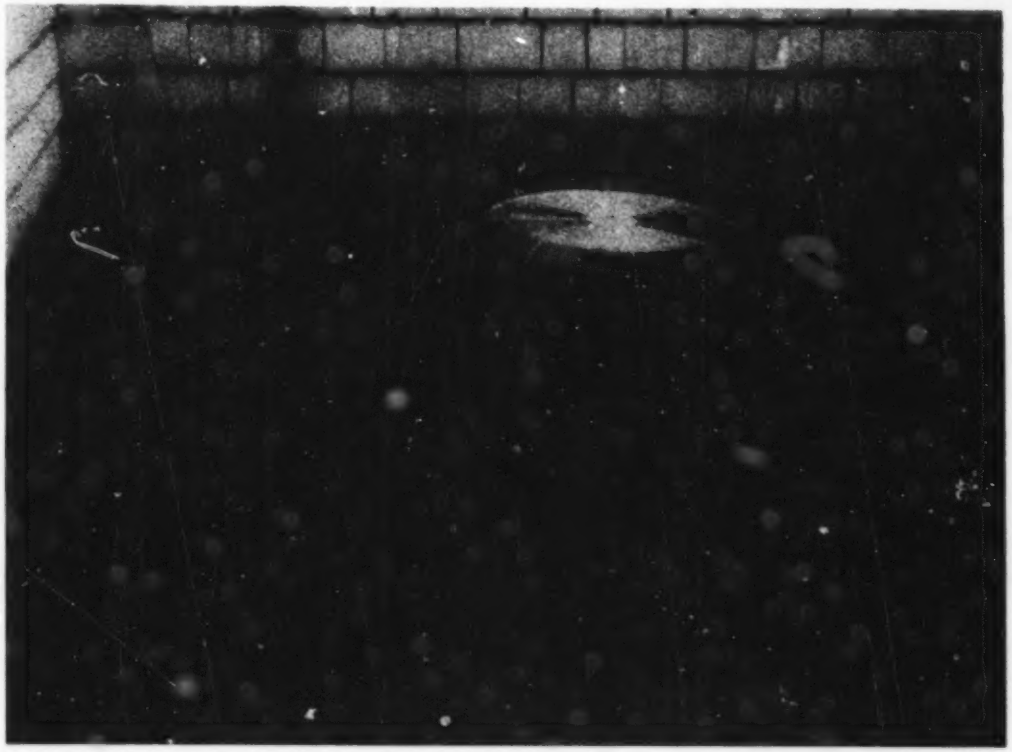
Description:

The existing heating system consists of a 160,000 BTU/hr (46,900 W) *"McClary"* hot air furnace with a separate 250 W (1/3 HP) circulating fan.

A *York, Model No. CHPA 24,* heat exchanger coil has been installed in the hot air plenum of the furnace. It is connected to a *York,* heating and air conditioner, Model No. *CHOP 24* unit outside the house.

A *"Yorkguard Computer"* controls both the hot air furnace and the heat pump, determining which should be used to heat the house, depending on the outdoor air temperature.

A separate kilowatt-hour meter is connected to the heat pump power lines to measure that portion of the total electric consumption used by the heat pump. With this information and past furnace oil bills, Mr. Wilmot can determine his energy savings.



Outdoor Heat Pump Unit

Performance:

Performance data were not available when this report was compiled.

The *York* supplier claims this heat pump system will operate at a co-efficient of performance (COP) of 1.9 at an outdoor temperature of -8°C (17°F). This means the unit will supply almost twice the heat energy it draws in electrical energy, the difference being made up by heat energy extracted from the -8°C outside air.

Economics:

The installed heat pump unit and controls cost about $3,400. The predicted energy savings amount to $970 per year at 1980 prices. Allowing for interest on the heat pump investment, Mr. Wilmot believes the unit will pay for itself in five years.

Comments:

Before installing a heat pump, be certain to have an electrician check existing wiring to determine if it can handle the additional load. In Mr. Wilmot's case, a new electrical entrance cost about $1,000.

Viewing:

Mr. Wilmot asks interested persons to telephone to make arrangements to discuss his project—**798-3328.**

Greenhouse Agriculture

5

Heating costs are one of the single largest expenditures greenhouse operators face. Rising fuel prices of the 1970s and '80s forced greenhouse operators to rethink building design and construction in an effort to reduce heating requirements.

Although smaller than most commercial operations, the greenhouses described in this section reflect the new emphasis placed by the industry on energy efficient design and operation.

Previously, greenhouses were built with glazing, often small single pane glass, used extensively on all exterior surfaces. They were rarely insulated, difficult to heat, poorly constructed for airtightness, and oriented along a north/south axis.

In contrast, the greenhouses described here are double glazed, well insulated, airtight, and oriented along an east/west axis giving them a southern exposure. This orientation permits insulation of the entire north wall. Fifty millimetres (2 in.) of rigid insulation is generally preferred because it is easy to install. Insulation levels vary from RSI-1.4 to RSI-1.7 (R-8 to R-10), depending on the type of rigid insulation used.

In modern greenhouse construction, rigid insulation is also used on the foundation below grade. Glazed areas are made of double pane glass or any of a wide variety of transparent synthetic materials. Heat loss, however, is still a problem. Insulated shutters are used to cover glazing at night, keeping greenhouse temperatures up and reducing the heating load.

Airtightness is of primary concern where glazing meets framing. In these greenhouses, silicone or an automotive type sealant is used to tightly seal glazing to the structure.

Ventilation is, of course, still required and is especially critical in summer months to counter the dangers of overheating. Thermostatically controlled, automatic vents are available for this important task.

Greenhouses are subject to extreme temperature fluctuations, especially in very hot or cold months. Thermal storage has been used successfully in a number of these greenhouses to lessen the temperature swings. The thermal mass, usually water or rocks, absorbs excess heat during the day and releases it when air temperatures inside the greenhouse drop below that of the storage medium.

While water can be stored in almost any type of container, its disadvantage as a thermal mass is that it competes for space with growing beds. Rocks, on the other hand, are used on the floor and therefore demand none of the valuable interior growing area. With rock storage, ducting, piping, and a fan or fans (as in the Castles' project) are used to enhance thermal storage.

Greenhouses constructed in the manner described here will extend the growing season to eight months of the year. If they are heated, as several are, they will provide an excellent environment for plant growth year round without the high heating bills traditionally associated with greenhouses.

Many of the techniques used in these projects also apply to attached greenhouses, sunspaces, and solariums. The greenhouses in this section, however, differ in that they are solely intended for plant production and do not supplement home heating or provide additional living space.

Solar Heated Commercial Greenhouse

David and Clare Castle
Middle Musquodoboit, Halifax County

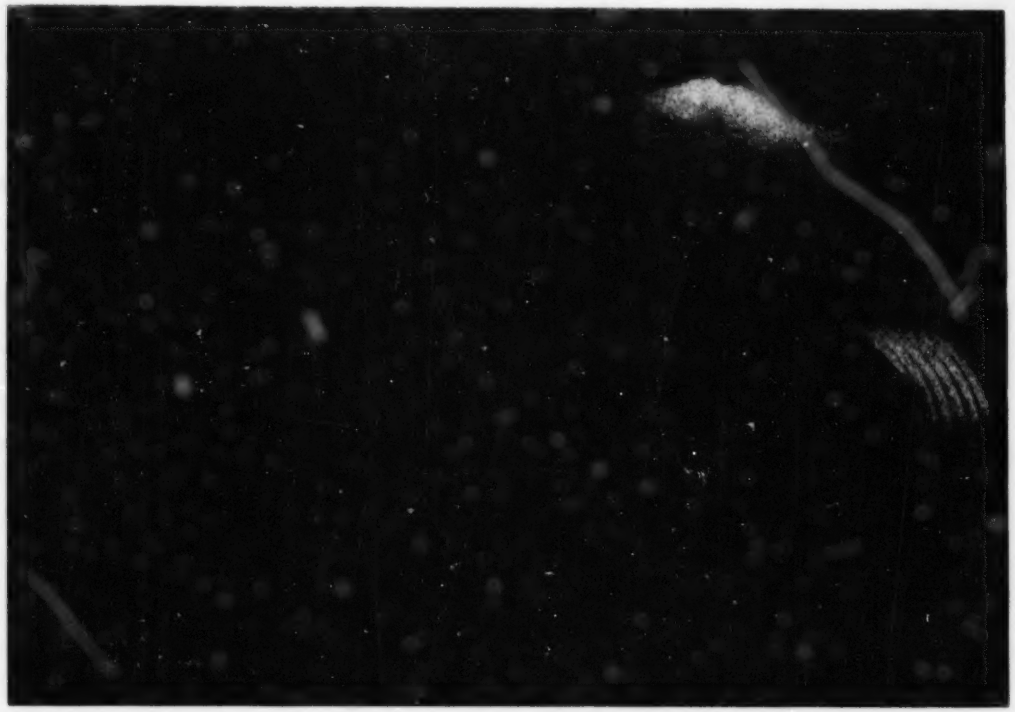
Purpose:

The goal of this greenhouse project is to produce winter tomatoes and English cucumbers cheaply enough to compete with imports from the United States. Heating costs should be lower than those of conventional greenhouses because the greenhouse uses a solar hot air heating system with thermal rock storage. Auxiliary heat is supplied by a wood furnace.

Description:

The greenhouse is a 9.1 m x 18.2 m (30 ft. x 60 ft.) structure using wooden beams and posts. The north wall and north slope of the double peak roof is covered with steel siding and 50 mm (2 in.) of rigid insulation. The remainder of this structure is covered with two layers of corrugated fibreglass panels with a 25 mm (1 in.) air space in between. Removable, rigid insulation panels are positioned against the inside of the fibreglass at night. Insulation extends 1.2 m (4 ft.) into the ground, around the perimeter of the structure, reducing heat loss from the rock storage and keeping frost out.

The floor was excavated to a depth of 1 m (3 ft.), covered with 50 mm (2 in.) of rigid insulation, and filled with 25 mm to 50 mm (1 in. to 2 in.) of stones. A header duct runs north-south under the stones. Perforated pipes run east-west from the header to the sides of the structure and then up to the surface. Fans in each peak will force hot air into the header and perforated pipe to heat the rock storage. At night, when the ambient temperature is lower than that of the rocks, heat from the rocks warms the air. Additional perforated plastic pipes disperse warm air from the rock storage to beneath the growing benches.



Commercial Solar Greenhouse

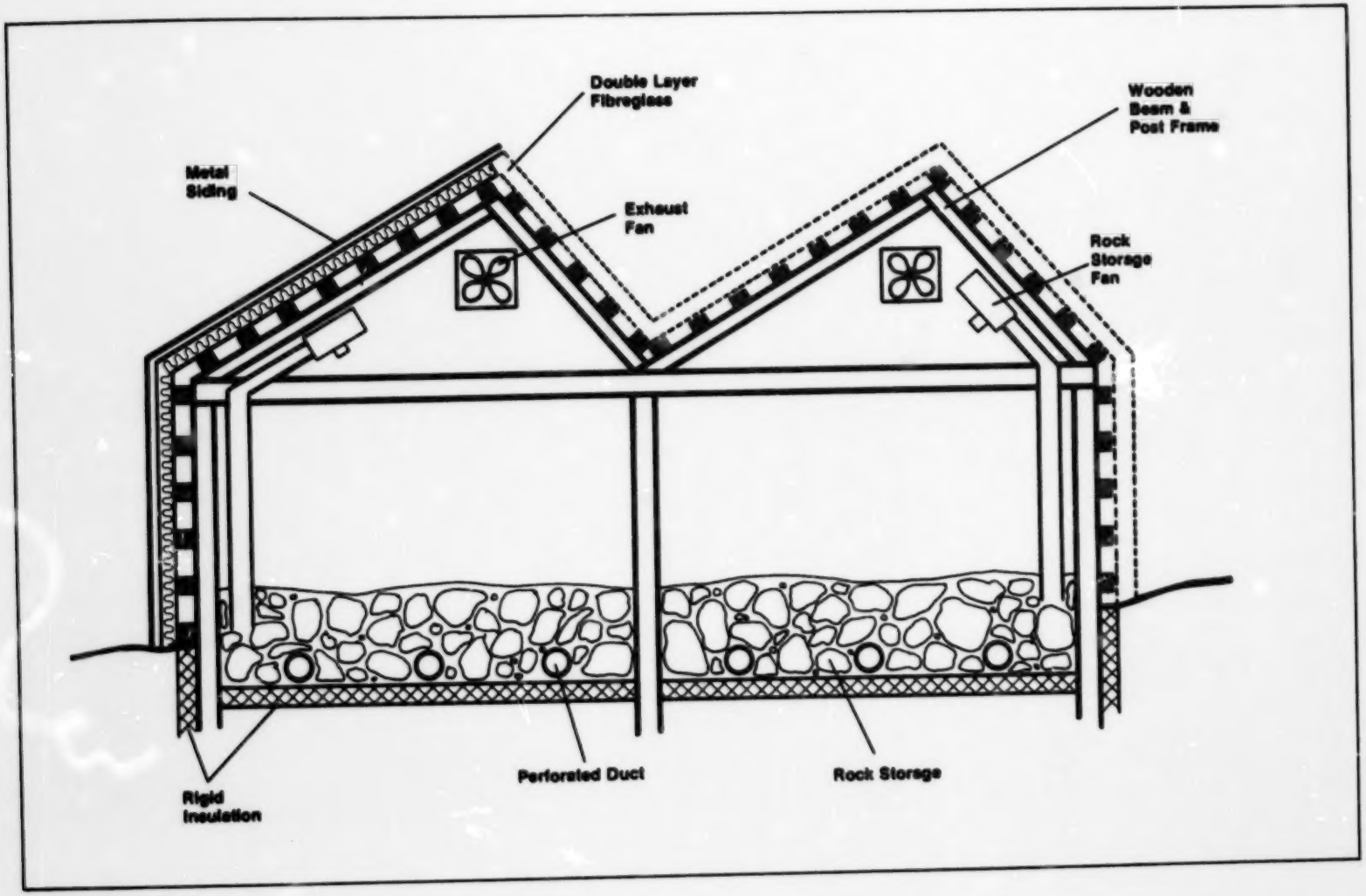
If the air temperature drops too low, an auxiliary furnace supplies the required heat. Should the temperature become too high, a fan in the west side of each peak can force the hot air outside. All fans are thermostatically controlled to ensure automatic operation.

Performance:

During the summer months, no overheat problems were encountered. Soil, rock storage, and minimum-maximum air temperatures were to be monitored during the 1981-82 winter. By the spring of 1982, the Castles expected to have a good idea of the greenhouse's winter performance.

Economics:

The greenhouse has cost the Castles approximately $12,000. It would be an expensive experiment for the Castles to finance without government assistance. The Department of Agriculture's greenhouse specialist has expressed interest in this solar heated greenhouse project, feeling the results may be of interest to other Nova Scotia greenhouse operators.



Cross-section of Greenhouse

After the first winter's operation, the Castles will determine the greenhouse's energy consumption and the final cost of the product.

Viewing:
Persons interested in discussing the greenhouse project with the Castles should phone in advance to make arrangements—**384-2070.**

Small Scale Urban Greenhouse

Douglas Gorveatte
Dartmouth, Halifax County

Purpose:

The greenhouse will be used to produce vegetables for family consumption during the winter months. Transplants will be started in the greenhouse during the early spring.

Description:

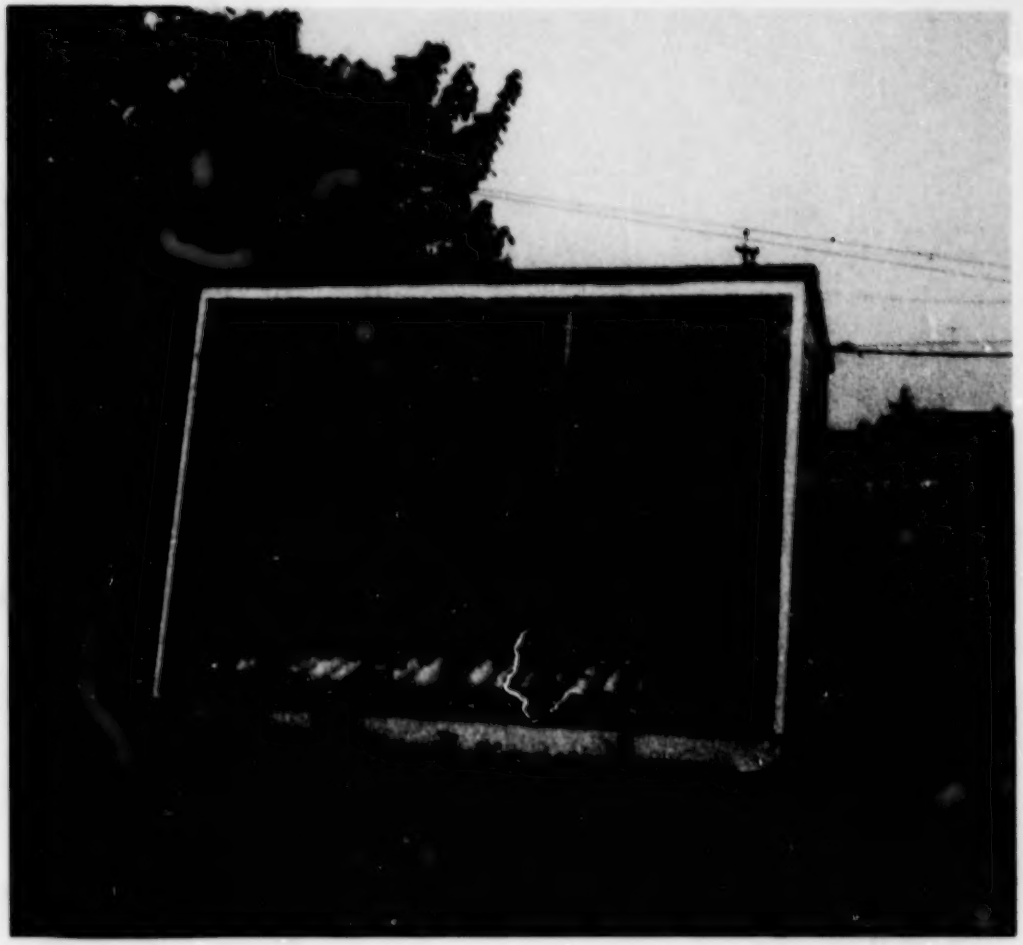
The greenhouse is a standard wood frame construction. The floor measures 2.4 m x 3.6 m (8 ft. x 12 ft.) while the ceiling is 1.8 m - 2.4 m (6 ft. to 8 ft.) high. Fibreglass panels *(Kalwall)* are used for glazing.

The structure is built on short, concrete posts. This avoids the problems and expenses of excavation, pouring concrete, and underground insulation. The floor is made of 50 mm x 300 mm (2 in. x 6 in.) framing sheathed on the top and bottom with fibreglass insulation in the middle.

The walls are made of 50 mm x 100 mm (2 x 4 in.) framing and fibreglass insulation. Aluminum plates were used on the interior for reflecting light and heat. Problems arose cleaning the aluminum so an alternate material may later be used.

Cedar studs were used where the wood comes in contact with the glazing. This eliminated the potential for wood rot. All other framing is spruce and was treated with wood preservative.

The fibreglass glazing was fastened directly to the cedar framing using silicon caulking, neoprene washered nails, and a 25 mm x 50 mm (1 in. x 2 in.) cedar strap.



Kalwall Glazing on Greenhouse Face

The entrance has an aluminum door on the outside and an insulated door on the inside. A wind break or double entry may be added this winter, if required. A 15.9 m^3/min. (560 cfm) thermostatically controlled electric fan is mounted in the roof for summer ventilation.

Two hundred and ten 4.5 L (1 gal.) water jugs will be used for heat storage. A black dye will be added to enhance the heat absorption properties of the clear jugs. If additional storage is required, more jugs can be added.

Performance:

The greenhouse was completed in mid-summer 1981. The Gorveattes had not evaluated its cold weather performance by the time this report was prepared. During the summer of

construction, difficulty was encountered with extremely high temperatures. The initial fan (rating unknown) proved inadequate so a 15.9 m^3/min. (560 cfm) fan was installed. The placement of the water storage did have a moderating effect on the temperature.

Economics:

This greenhouse project has cost Mr. Gorveatte approximately $800. The wood framing and glazing were the most expensive components.

Comment:

The final cost of this type of project is highly dependent on the builder's ability to procure materials at less than retail cost. In the Gorveattes' case, the 210 water jugs were obtained free and the fan was purchased on sale.

On another project, double glazed, patio door glass was obtained at a low cost due to dimensional flaws.

With a little time and investigation, a greenhouse can become an inexpensive investment.

Viewing:

Anyone interested in seeing the greenhouse should telephone Mr. Gorveatte at **434-1846** (home) or **835-3778** (work).

Solar Heated Pit Greenhouse

IMA Aquatic Farming Limited
Argyle Head, Yarmouth County

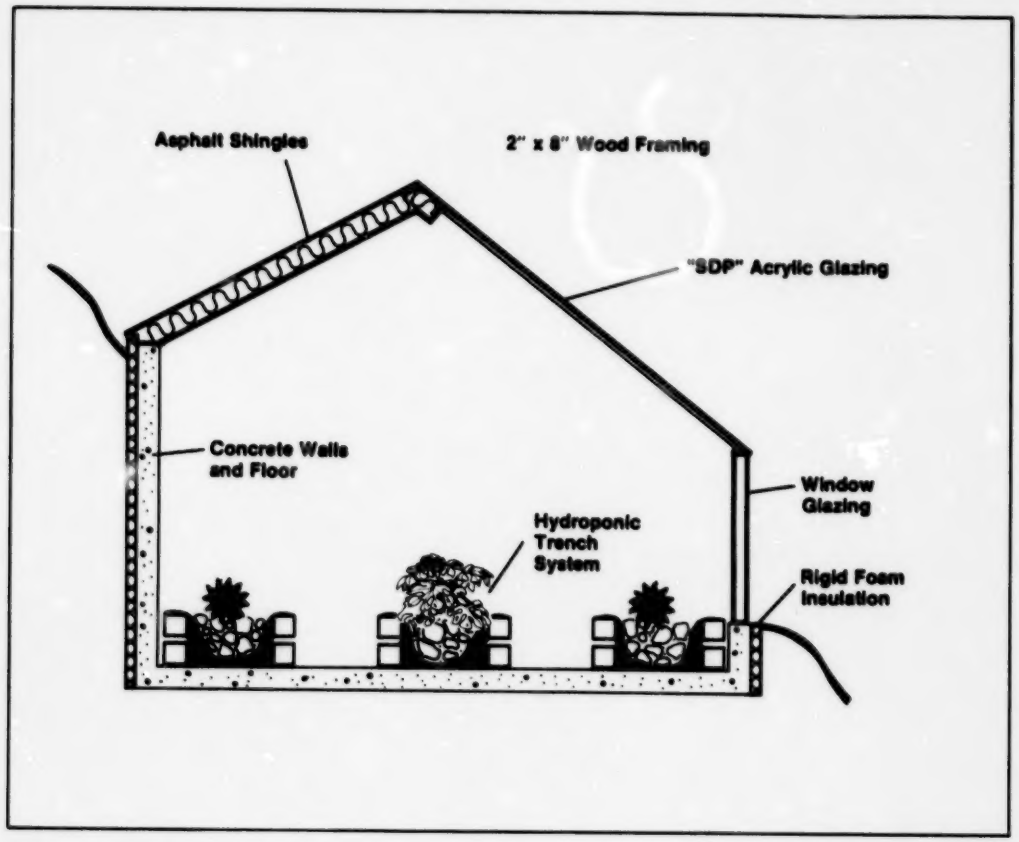
Purpose:
The IMA greenhouse will combine a solar greenhouse and a hydroponic growing medium. The hydroponic system will "scrub" effluent from a salmonid hatchery before returning it to the watershed. Vegetable produce will be grown and sold if proven to be economical.

Description:
The greenhouse is a 9.1 m x 4.6 m (30 ft. x 15 ft.) wood frame structure, built into a hill. The greenhouse faces south. Its exterior concrete walls are covered with 75 mm (3 in.) of rigid form insulation RSI-2.6 (R-15)while its roof has 200 mm (8 in.) of fibreglass batt (RSI-5.6) insulation.

An acrylic, double wall glazing system (SDP) forms the main, southern exposed glazing. The short, vertical front wall and the end walls are covered with double glazed windows. Rigid insulation panels will be placed on the inside of the glazing at night to reduce heat loss.

Two of the front windows and two of the small, upper acrylic panels open for natural ventilation. These vents are automatically controlled by heat activated, compressed gas mechanisms called *"SolarVent"*. A thermostatically activated electric fan ensures adequate cooling.

The hydroponic system consists of three trenches running lengthwise through the greenhouse. Each trench is made from cinder blocks lined with sand covered by a plastic film. This watertight plastic trench is filled with gravel. Effluent leaving the hatchery is held in a settling tank, then piped into the



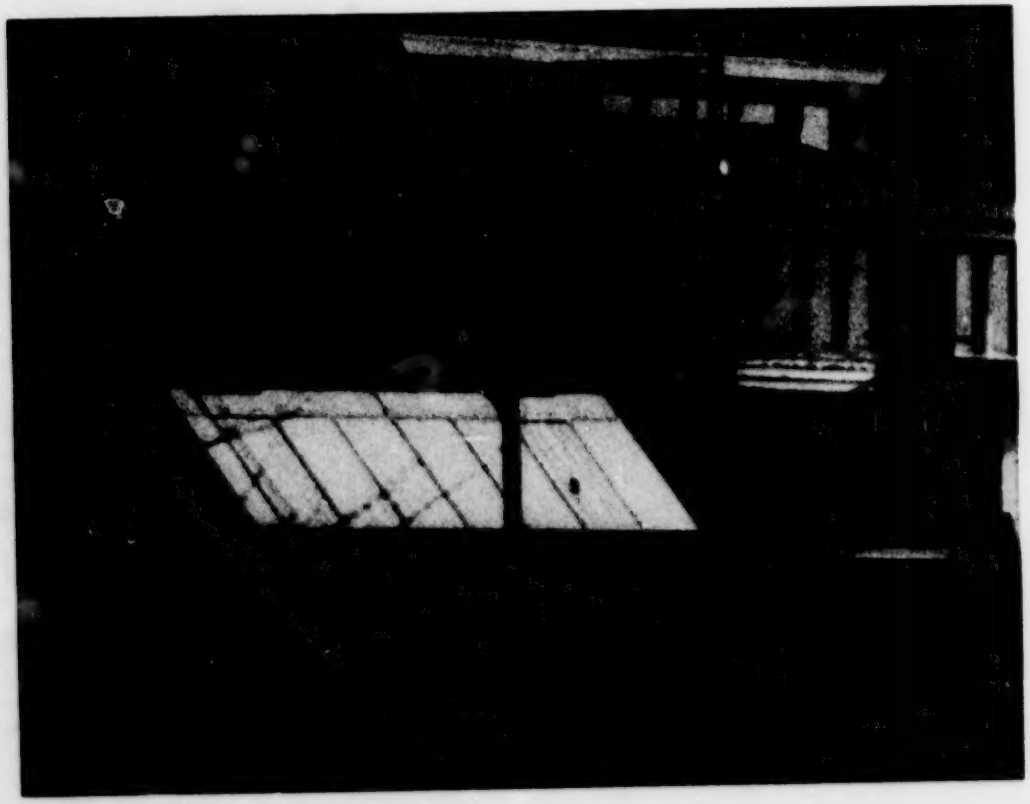
Cross-section of Greenhouse

greenhouse, flooding the trenches. Watercress plants, growing in the gravel, "scrub" the effluent before it is released from the trenches and allowed to return to the watershed.

Heat for the greenhouse is supplied by the sun and the effluent (groundwater at 8°C or 46°F). The effluent also aids summer cooling, as its temperature varies only slightly throughout the year.

A heat pump system is also used. It warms the hatchery water and the resulting effluent. When this system is operational, the temperature inside the greenhouse will be high enough to allow the growing of vegetables such as tomatoes, lettuce, and herbs.

Performance:
As part of IMA Aquatic's scientific approach to aquaculture, detailed measurements are being kept on inside and outside water and air temperatures as well as solar radiation intensity and duration. This information will permit IMA staff to calculate the total solar gain per given area as well as PAR (photosynthetic active region) required to monitor plant growth. These data will be useful to prospective



Solar Greenhouse (foreground) and Hatchery

builders of commercial or domestic, solar heated greenhouses.

Evaluation:

The greenhouse performs the valuable operation of environmental protection through effluent purification without additional energy input. It may also add commercially marketable produce to the IMA hatchery sales.

The total cost of the greenhouse facility will be approximately $12,000. All the materials are new and of high quality. The value of the vegetable produce will not be known until the first crops are grown and sold.

Viewing:

Persons wishing to view or discuss the operation should telephone to make arrangements—643-2700.

Free-Standing Solar Greenhouse and Water Pumping Windmill

Jan and George Post
West River Station, Pictou County

Purpose:

The greenhouse will extend the Nova Scotian growing season for more sensitive plants and store the sun's energy as sensible heat. The windmill will increase the Posts' water pumping capacity without increasing their dependence on electricity.

Description:

The greenhouse is a free-standing, masonry structure measuring 3.8 m x 6.2 m (12 ft. x 20 ft.). The 1.25 m (4 ft.) deep foundation, north wall, and portions of the east and west walls were made of concrete using the slipform method. A section of wall measuring approximately 0.6 m x 2.5 m (2 ft. x 8 ft.) is poured. When the concrete hardens, but while it is still green, the form is moved to the next location. This technique saves form material and is ideally suited to hand-mixed concrete batches.

On the wall sections above ground, rocks were set in the wet concrete, inside the form. When the form was removed, the concrete was chipped from between the rocks. The result is a very attractive, masonry wall. (A barn foundation on the property was constructed in the same manner and has endured three winters without cracking.)

The roof, side walls and glazing frame are all constructed of 50 mm x 150 mm (2 in. x 6 in.) cedar lumber. The framing is rabbetted. The commercially produced, tempered, thermopane glass fits flush with the framing. Automotive sealant strip holds the glass against the framing.

Solar Greenhouse of Slip-form Construction

The concrete walls are insulated with 50 mm (2 in.) of rigid foam insulation and the wooden walls are insulated with 150 mm (6 in.) fibreglass butts. Both the east and west walls have doors which serve the dual purpose of access and ventilation. A rotary roof vent has also been installed.

The north slope of the roof is covered with galvanized roof panels. This material is very durable (if painted) and is very common for agricultural buildings.

When the excavation was performed for the foundation, only a narrow ditch was dug around the perimeter of the building. This made backfilling much easier, as the interior was already filled. Plants will be grown in tiered wooden benches, allowing full solar exposure.

The water pumping windmill is a conventional unit of a type found on most North American farms until the 1930s. The unit converts the rotation of the windmill vanes into an up-and-down motion. This linear motion drives a piston lift pump. It is placed approximately 10 m (30 ft.) beneath the water level in the Posts' 31 m (100 ft.) deep drilled well.

The *"Dempster"* windmill is mounted on a 10 m (30 ft.) free-standing, galvanized steel

Windmill Used for Pumping Water

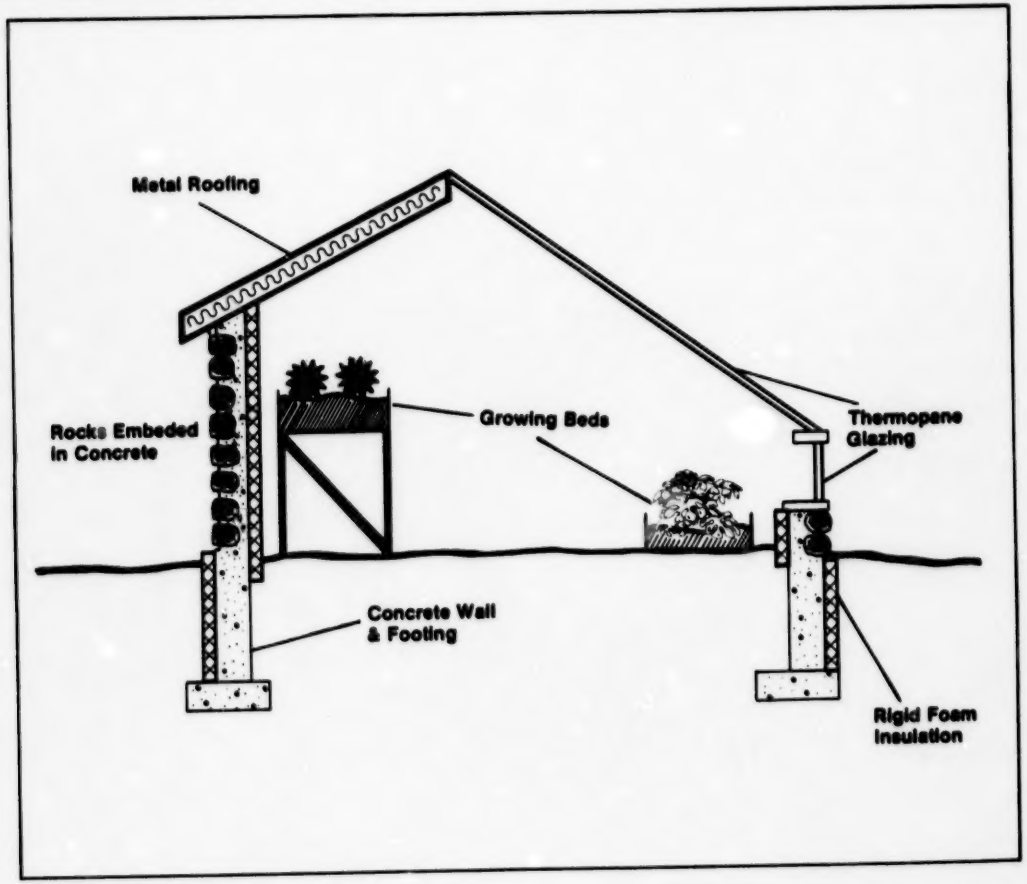
tower directly over the well. The windmill itself is of a time honoured design. It is reliable due to its simplicity but it is technically inefficient at extracting energy from the wind.

Water pumped from the well runs either to the house or down the other side of the hill to the greenhouse and garden.

Performance:

The Posts intend to use their greenhouse as a season extender. Their structure has no auxiliary heat, so the temperature inside will drop to freezing in the late fall. However, it will hold the sun's heat in its mass, permitting them to grow plants much later than is possible in a garden. When the hours of daylight get shorter and there is a chance of freezing temperatures, the Posts plan to grow hardier vegetables, such as lettuce.

This fall and next spring the Posts will be recording the minimum and maximum greenhouse temperatures with a min.-max. thermometer. This way they will know what to expect next year.



Cross-section of Greenhouse

Economics:

The windmill is an exercise in energy self-sufficiency, reducing the Posts' dependence on electricity to only lighting, refrigeration, and entertainment. The greenhouse will eliminate the Posts' dependence on imported vegetables. The greenhouse cost $3,400, most of which was spent on commercially supplied glazing. The windmill cost approximately $2,400. Both projects are well built and should be producing vegetables and water respectively for years to come.

Viewing:

Anyone interested in seeing the project should call in advance to make arrangements—**925-2510.**

Free-Standing Pit Greenhouse

Alexander Robertson
Keppoch, Antigonish County

Purpose:

The greenhouse is intended as a growing season extender for crops which might not otherwise mature in the short Nova Scotia summer.

Description:

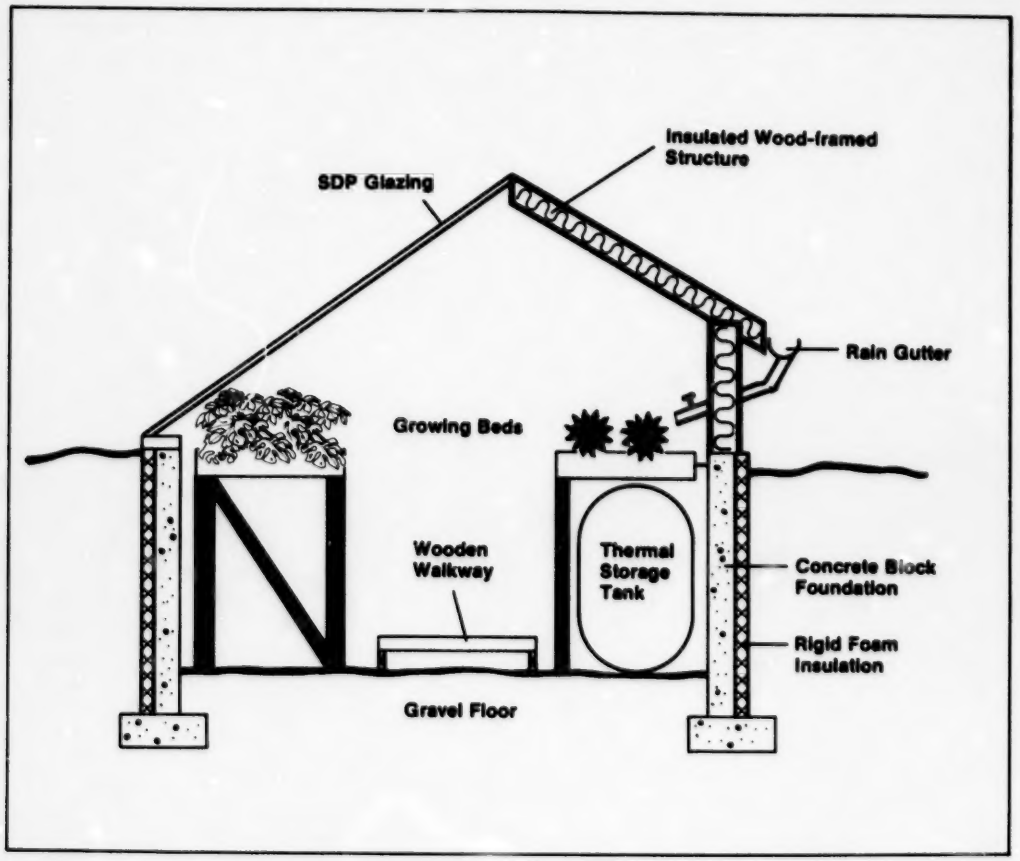
The 3.8 m x 5.6 m (12 ft. x 18 ft.) greenhouse is built on a 450 mm (18 in.) wide, reinforced concrete footing, 1.25 m (4 ft.) below grade. Concrete block walls are built on top of the footing, extending to about 150 mm (6 in.) above grade.

The upper walls and roof are framed with 50 mm x 150 mm (2 in. x 6 in.) lumber on 600 mm (24 in.) centers. The non-glazed walls are covered with pressed, black sheathing and vertical rough lumber siding. The roof is covered with asphalt shingles.

The concrete walls are insulated with 50 mm (2 in.) rigid foam insulation applied on the outside, bringing the thermal mass of the walls within the heated envelope. The structure's wooden portion is insulated with 150 mm (6 in.) fibreglass batts covered with a 6 mil vapour barrier and plywood.

The glazing consists of four *"SDP"* acrylic panels. These are a commercially produced, semi-transparent, double wall panel designed for greenhouse use. The SDP panels are fastened to the wood framing with screw-on plastic strips. Silicon caulk ensures a watertight seal.

The floor of the greenhouse is made of 200 mm (8 in.) washed, crushed stone. A 760 mm (30 in.) wide wooden walkway runs down the middle of the floor.

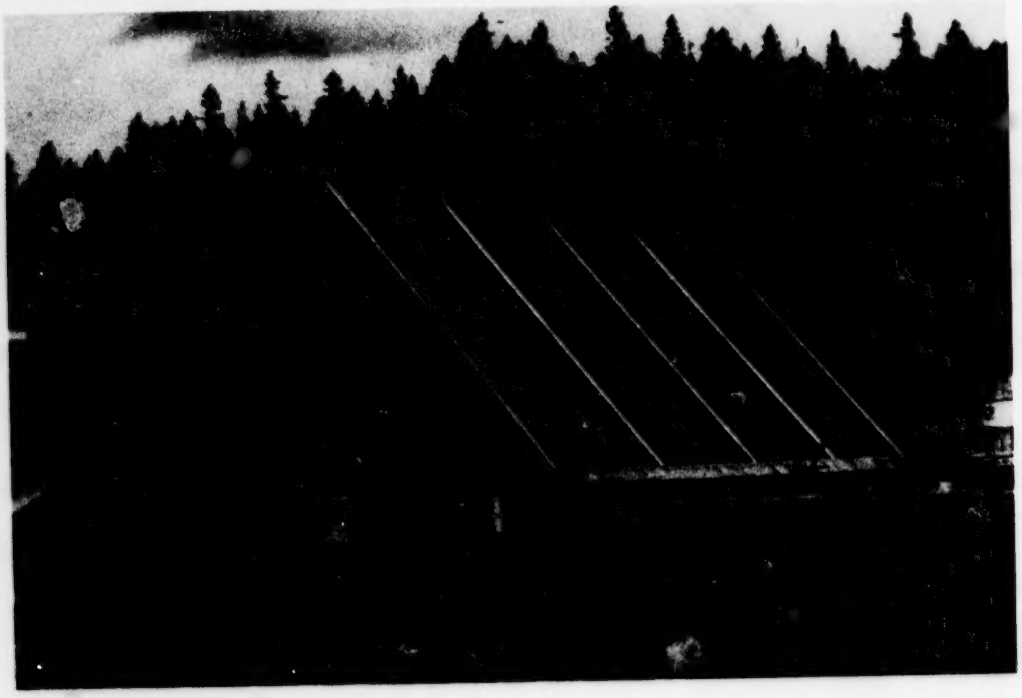


Cross-section of Greenhouse

The plants are grown in raised wooden benches on both sides of the walkway. Beneath the rear bench are two, 920 L (200 gal.) oil drums filled with water. Along with the foundation and floor, these provide mass for thermal storage that moderates air temperature fluctuations throughout the day.

Two vents, each 0.2 m^2 (2 sq. ft.) in area, are built into the east and west walls near the peak. These are opened and closed automatically by gas-filled devices called *"SolarVent"*. As the temperature increases, a liquid within a hydraulic cylinder changes to a gas. This volume change produces a pressure that opens the vent. When the temperature decreases, the gas becomes a liquid again, and springs close the vent.

Access to the greenhouse is through a hatch, stairwell and insulated door. This system provides an air lock that helps retain the heat within the greenhouse.



SDP Glazing on Pit Greenhouse

An eavestrough was installed on the rear roof to catch rainwater for the plants. The downspout runs through the rear wall into a barrel.

Performance & Economics:

The entire structure cost approximately $3,000, plus much labour. The building has no auxiliary heat and so cannot sustain plants all year. Since the greenhouse is not attached to the house and therefore cannot help heat the house, its usefulness is measured by the plants produced.

On one cool November day, with snow flurries in the air, the inside temperature was 23°C (74°F). The minimum inside temperature during the previous night had been 6°C (42°F).

Viewing:

Mr. Robertson asks those wishing to visit his project to phone him at home during the evening to make arrangements—**863-5578.**

Innovative Construction

6

As the title implies, these projects represent advanced concepts in applying renewable energy and conservation to single family dwellings. Despite their diversity of methods, their owners share a common goal: to construct a home that requires as little heating as possible. This is accomplished by using two basic concepts: super insulation and airtightness.

Techniques of double wall construction allow levels of insulation impossible to achieve with standard stud wall construction. In fact, it is possible to the point where merely the heat given off by human activity (lights, appliances, etc.) will keep indoor temperatures at a comfortable level. However, when you compare the fuel savings in a super insulated house in Nova Scotia with those of a merely well insulated house, the additional costs of materials and labour for super insulation do not seem justified.

What constitutes super insulation? Current levels of insulation generally considered cost-effective in new home construction are RSI-6.1 to RSI-7 (R-35 to R-40) for ceilings, RSI-3.5 (R-20) for walls, and RSI-2.1 (R-12) to RSI 3.5 (R-20) for basements. A home with insulation levels beyond these can be considered super insulated.

It is now recognized that airtightness in a home is just as critical as high levels of insulation in reducing heating costs. Sealed vapour barriers, airtight windows and doors, and sealed piping and wiring entrances/exits are getting the most attention, with special emphasis on the vapour barrier.

Air-to-air heat exchangers are being recognized as necessary in extremely airtight homes to combat moisture and odor problems. They bring fresh, dry outside air into the house while removing stale, moist indoor air. As humid inside air is exhausted, its heat is extracted and transferred to the incoming fresh air. This prevents humidity problems common in airtight construction.

Multiple sources of home heating is a common feature of these houses, especially the Seiler's and Prowses' homes. Both homes use wood as the primary heat source and make use of solar energy when it is available. Backup conventional heating systems ensure heat will be available at all times. These backup systems are especially critical should it be necessary to leave the home unattended for extended periods in winter.

Active solar heating is used in the Prowses' home; water heat storage permits it to be integrated with the other heating systems in the house. However, this is an extremely expensive system to purchase due to the high cost of the collectors.

The unique feature of the Seiler's home is the Trombe wall and the extensive air handling system to transfer heat throughout the dwelling. Proper orientation is a critical factor in any new passive solar home.

Innovative construction techniques such as those used in these projects impart character and personal style to a home, while reducing heating needs and fuel cost for the owner. As these projects show, innovative construction techniques need not result in a home that is unconventional in appearance.

Lower fuel costs, however, can also be achieved using standard home designs and building techniques, provided high levels of insulation are used, and priority is placed on airtightness.

An Active Solar/Wood Heating System

James and Maria Prowse
Sambro Head, Halifax County

Purpose:

When James and Maria Prowse decided to build a new home, they opted for solar energy to minimize their heating costs. The heating system they chose consists of a water-filled heat storage tank, solar collectors, a wood furnace, and electric heaters (as back-up).

Description:

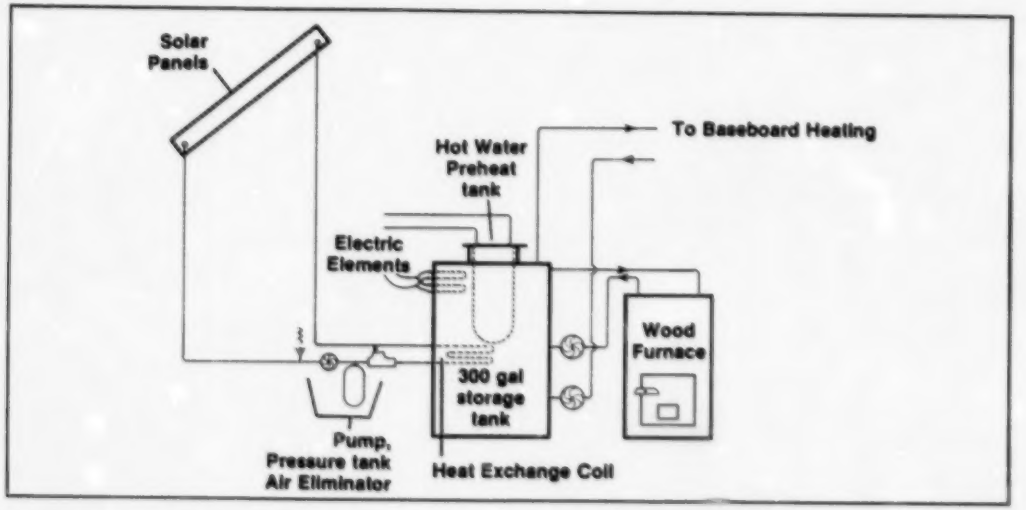
The heart of the home's heating system is a 1364 L (300 gal.) steel storage tank fabricated by Parrsboro Metal Fabricators. The cylindrical tank has a large hatch on the bottom to permit inspection and servicing. It has pipe fittings on the side for connection to a Kerr wood furnace. A copper heat exchange coil for the solar system is built into the tank as are fittings for three, 1000 watt immersion electric heaters. A 91 L (20 gal.) domestic hot water tank sits in the top of the storage tank.

The Prowses chose to build an *Ecohab II* home offered by *Habitations International.* The house has a cathedral ceiling design with a large sloped shed roof that has been oriented toward the south.

While the house was under construction, steel plates with attached pins were fastened to the roof decking. The pins project through the roof shingles, providing a support for the angle iron collector mounting frame. This system distributes the weight of the collectors while minimizing the number of roof perforations.

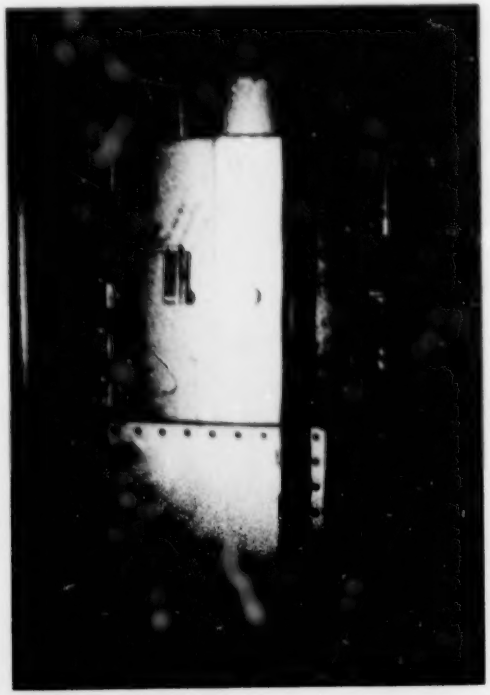
Ten "Sunline" solar panels were mounted on the roof of the house on a 60° angle. These

Rooftop collector array on Southern exposure



Schematic of heating system

Closeup of solar collectors



Boiler of wood/solar heating system

panels are a single glazed unit with tempered glass. They were sold through Parrsboro Metal Fabricators.

Insulated copper piping carries the glycol from the roof to the basement. Located in the basement are a circulating pump, an air eliminator to remove entrained air, an expansion tank to maintain pressure within the loop, and a differential controller to operate the circulating pump. Since the potable water is within a separate tank, it is separated from the solar system antifreeze by two layers of metal. This constitutes a double wall heat exchanger, permitting the use of less expensive, toxic glycol.

Two valves and two drains in the solar system piping allow the separation of the exchanger and solar panels. This will facilitate maintenance on either section of the loop.

Water circulation between the *Kerr Scotty* wood furnace and the storage tank is controlled by two thermostats. Water temperature within the actual furnace boiler is kept high to minimize creosote formation.

The differential controller activates the glycol circulation pump whenever the collector panels are hotter than the water in the storage tank. The Prowses can determine whether or not to fire the furnace based on the temperature of the water in the storage tank. If the solar system heats the water in the tank to 60°C (140°F), a firing is not required.

A conventional wall thermostat in the house controls the pump that circulates water from the storage tank through the baseboard heaters. A second thermostat, set at a lower temperature, controls the electric emersion heaters. The heaters only raise the storage temperature to 37°C (100°F), thereby keeping the house from freezing while using a minimum of electricity.

Performance & Economics:

Mr. Prowse didn't manage to install the collectors before the 1982 heating season. During that winter, the house was heated entirely with wood. The winter of 1983 will be the first heating season for the solar system. The solar contribution to heating the home should appear as a decrease in wood use.

The total heating system cost about $8,000. Many of the components were bought at very competitive prices, since Parrsboro Metal Fabricators wanted to move these items. The 1364 L tank, however, was specially fabricated for this project.

Viewing:

Persons wishing to view the project should call in advance to make arrangements — **868-2552.**

Energy Storage Within a Concrete Slab

Joseph and Barbara Seiler

Bedford, Halifax County

Purpose:

The Seilers planned a new, energy efficient home that will incorporate a computer monitored, air movement system to optimize the performance of three alternate energy features. In addition to a conventional electric heating system, the house has a woodstove, Trombe wall, and ventilated concrete slab.

Description:

The new house is built on a south facing hill. The majority of the main floor level is on a concrete slab. Only a small portion of the house has a full basement. The slab was poured in two stages. During the first stage, 6.3 cm (2.5 in.) of concrete was poured over sand and polystyrene insulation, RSI-2.6 (R-15). Corrugated roof steel then was laid over the concrete to form ductwork to direct air through the floor in a carefully designed, serpentine pattern. Over this, another 6.3 cm (2.5 in.) layer of concrete was poured.

Hot air from the woodstove and Trombe wall circulates through the concrete floor and radiates up through the concrete. Thus the floor combines heat storage and heat distribution functions.

A series of vertical ducts built into a wall near the center of the house draw hot air from the woodstove and move air to or from the den and the upstairs hall. In the den, directly behind two-thirds of the home's windows, stands a 7.3 m^2 (75 sq. ft.) concrete Trombe wall. The wall is enclosed in a box structure with provision for allowing heated air directly into

Southern exposure with Trombe wall on interior of room

the den or for sliding insulation panels over the windows to reduce heat losses at night. Two ducts are used to draw heated air from the box structure and to return cool air.

Hot air from the concrete floor, woodstove and Trombe wall are all circulated by a central, reversible fan. By changing the position of the dampers, various heating functions can be performed. These include distributing excess heat from the woodstove to the concrete floor or moving heated air from the Trombe wall to the upstairs hall.

Essential to the efficient operation of the system is an intelligent temperature monitoring system (a microprocessor) to optimize use of the stove, dampers, shutters, and fan. Once the optimum method has been found, the system will provide maximum return. Methods of operation can be verified with recorded data.

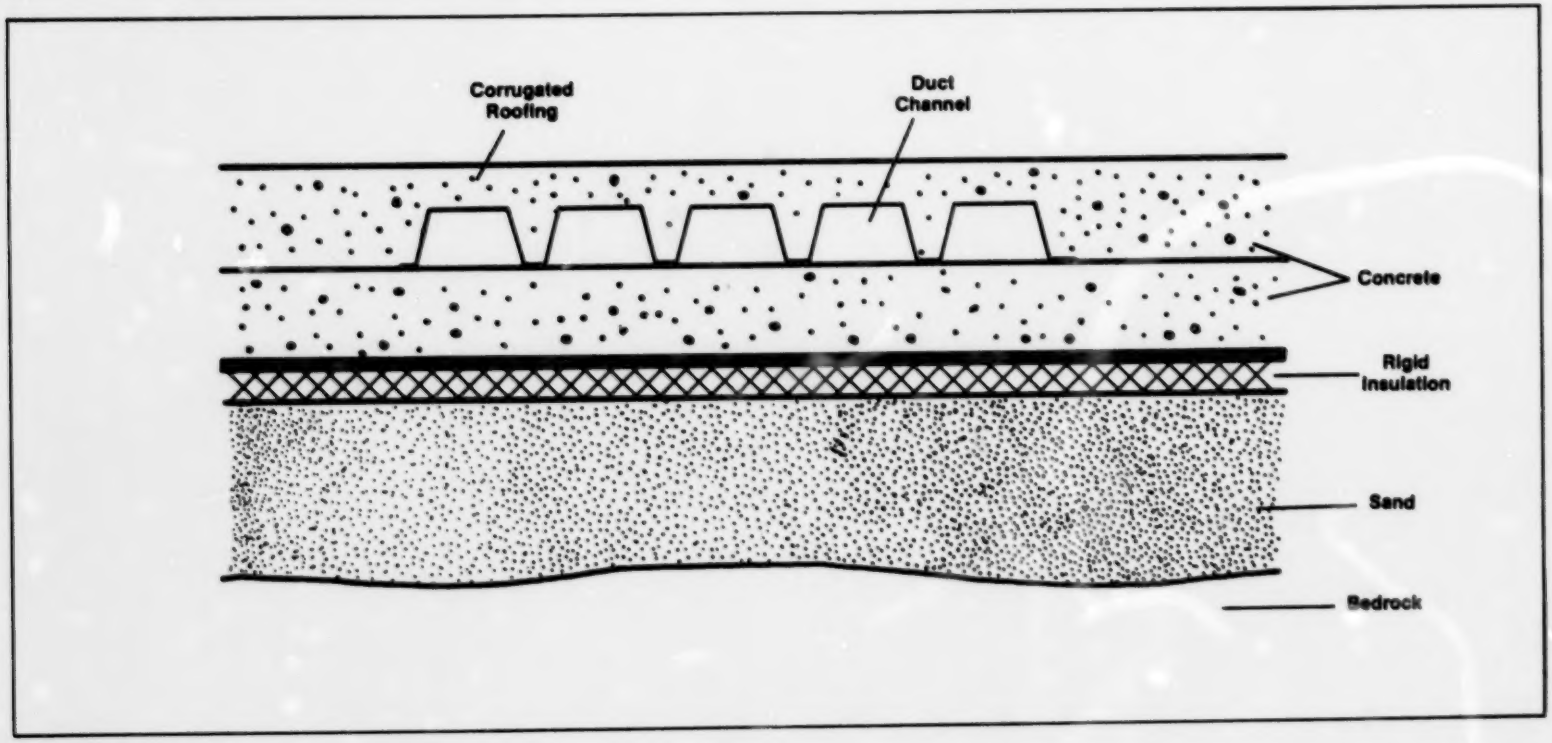
The system's performance will improve with operating experience. For instance, although a temperature may be established at which it is best to close the shutters, unless the occupant constantly checks temperature readings, the optimum time to close the shutters may be missed. By employing a full time monitor the occupant will be alerted the moment optimum conditions for operating a system exist. Thus, the desired actions can be implemented more precisely. Further, an unneeded fan can be shut off and that energy conserved, too. The monitor makes it possible to squeeze those extra BTUs from the system.

When the air passages were being constructed in the concrete floor, Mr. Seiler laid a flexible copper tube in one passage. This tube is filled with incoming water to the electric water heater and acts as a water preheater.

Performance:

It is expected to take some time before the Seilers perfect the system. Mr. Seiler could not obtain one component for the microprocessor so it did not operate until late in the 1981-82 season. Meanwhile, the Seilers were becoming accustomed to the performance of the system's components and how they interact. Upon completion, the microprocessor must be programmed and each input variable quantified. Mr. Seiler plans to prepare a report on the system after one year of operation.

The incremental cost of the heating system is approximately $8,600. The combination of a well insulated, airtight house and the passive solar system should produce a very low annual heating bill.



Ventilated concrete slab-sketch

Viewing:

Please phone the Seilers to make arrangements to visit their house—**835-9255**.

Various Solar Fixtures on Innovative Farmstead Structures

Geerten de Boer
Unlimited Resources Institute, Canada Creek, Kings County

Purpose:
Unlimited Resources Institute began work towards its goal of self-sufficient farming during the spring of 1978. When completed, this installation will provide and demonstrate:

- the principles of integrated, appropriate technologies (employing sun, wind, wood, water, and manure) used to support a 186 m^2 (2000 sq. ft.) structure at Canada Creek, Nova Scotia
- data/information relevant to energy self-reliance
- a focus for students on buildings, site planning and design, material handling, and energy technology relevant to realistic rural self-support.

Through the participation of volunteer staff, including some 1500 visitors to date, and of organizations such as Katimavik, Atlantic Canada Energy Strategy Society, and the Solar Society of Canada, a valuable resource for the community and region is assured. The farming operation will be self-sufficient once the energy systems are completed.

Description:
The following description was prepared by Unlimited Resources for Ken Kern's 2nd edition of *"The Healthy Home"*, Owner Built Publications, Oakherst, California, U.S.A.

Tower centres greenhouse structure at farm project

In 1978, the building for the workshop was completed. Referred to locally as the "mud hut", its floor and walls are an earth cement mix (1:6). A slip form was used for the wall construction—walls are finished with fibreglass/stucco 3 mm or 1/8 in. thick, portland cement and lime). Wire anchors hold down an expanded exterior and applied stucco is made of sifted earth and portland cement (2:1).

Two, 910 mm (3 ft.) high trusses are fabricated of recycled lumber-post. Tension is maintained with steel cables and turnbuckles. Roof beams are local spruce trees (8" diameter—top) split through the centre with a chain saw.

The roof is covered with recycled tongue and groove 25 mm (1 in.) lumber, 100 mm styrofoam, built-up roofing (tarpaper and tar) and sod.

The doors consist of two sets—i.e. insulated shutter doors and solar doors. The solar set are transparent (double glazing with *exelite*). By opening the insulated set of doors during sunny fall, winter and spring days, a great deal of heat is stored in the floors and walls.

A woodstove supplements heat from the sun, using 150 mm (6 in.) well casing for a chimney.

Material costs were approximately $2,500 of which more than half was spend on insulation.

In the summer of 1978, the floor of the adjacent house structure was poured; the building site had been scraped by a bulldozer down 910 mm (18 in.) to bedrock. The floors consist of 50 mm (2 in.) styrofoam supported by bricks (leaving an airspace) covered with 50 mm of ready-mix concrete. The first winter, the floor was covered with 500 mm (20 in.) of hay, to prevent damage. The floors in the main rooms have now been finished with local granite, slate and bricks.

All walls are concrete and built using slip-forms. (Mixing clean gravel instead of earth proved less tiring.) Only the large circular room contains wood in the form of stackwall. The mortar used is a vermiculite cement mixture with approximately the same insulation value as wood.

Interior walls are plastered. Exterior walls are covered with styrofoam, diamond lathe and earth cement with fibreglass and stucco.

The shed style roof is made of recycled barn beams, and covered with 50 mm (2 in.) spruce, 100 mm styrofoam, 6 mil poly, 22.7 kg (50 lb.) asphalt paper and 200 mm (8 in.) of sod. Styrofoam is used throughout as an insulating material. At the time, it had the best R-value/dollar return. Triple glazing will be used consistently (single glazed windows and thermopane and Heat Mirror).

The greenhouse will be covered with a fibreglass dome. The three story utility tower is constructed with ferro cement on a wood frame. The first story contains a composting privy with a clean-out in the greenhouse. The second has a sink, shower, and hot-tub. The third story has storage for hot and cold water, a widow's walk, battery storage, and wind generator (*Kedco, model 1200,* 1900 W/24 volts DC with a 70 amp alternator).

The south side of the tower above the greenhouse will be covered with solar hot water collectors (9.3 m^2 or 100 sq. ft.). These will thermosyphon heat into the storage through water, gravity fed, pumped to the storage level.

The south, east and south-west facing windows (46.5 m^2 or 500 sq. ft.) allow heat from the sun to be stored in the heavy building mass. The rooms around the livingroom core serve as an additional dead-air space (insulation) to the living core. Only in December/January will back-up heating be required. Shutters insulate the windows at appropriate times. Heat Mirror (a transparent reflective window applicant) and stationary insulation provide an equivalent of RSI-.87 (R-5).

A five foot diameter ceramic stove provides the additional heat source. This apparatus integrates oven, smoker, cooking range, water heater and dehydrator as well as fireplace. Air from the exterior is used to burn wood, peat or coal. From the space under the floor, air is heated to create circulation. Drafts go under the floor instead of over the floor.

The freezer/refrigerator unit is built-in. An icebox, filled with containers frozen into place in winter (with water) will create the freezer.

The whole structure will be banked in at least three feet of earth except where there are no doors. On the north side, the walls will be banked to the roof line, except where windows prohibit. Access to both the ice-box and wood storage area is through the roof.

The structure is one storey overall except for the three-storey utility tower and a two storey bedroom tower.

Performance:

The main farmstead structure was occupied for the first time in the fall of 1981. Its performance was probably not representative during the first winter since many little features were not completed. Much of the interior finish work and the greenhouse construction remained to be done. Geerten de Boer completed this during the winter.

The workshop has been occupied intermittently for several years. It is easily heated by a tiny airtight stove and is reported to be comfortable.

Both structures endure the weather well and have not developed any cracks in the concrete walls and floors. Some problems occurred with the ice-box but they were rectified.

Economics:

Construction techniques used to build the structure are very labour intensive; therefore a large portion of the money spent to date has gone for labour. Because many facets of this project had not been tried before, people involved in the construction have proceeded cautiously.

The building cost approximately $30,000. Although some of the materials were recycled, all the materials used were of high quality.

The actual economics of living in a building of this type have not yet been determined. The actual building costs are low when you consider the size of the structure and a second house could probably be built even more cheaply. Living in such a house would require a change in lifestyle for the average Canadian but one which could be easily adopted.

Viewing:

Geerten de Boer asks those who wish to visit the house to call in advance and make arrangements—**538-3377.**

Water Power

7

Small scale hydro has become increasingly attractive to those seeking an alternative to today's rising energy costs. Recent improvements in the water trubine generators have made the technology increasingly viable.

There are literally thousands of locations in Nova Scotia suitable for small scale water power development. These include sites used in the 1800s to generate mechanical power for various tasks, as well as small streams and brooks with sufficient flows to generate electricity for private residences.

Under the right conditions, small (micro) hydro installations can be very economical, however, they are initially expensive and represent a long-term investment. Although they require much patience and care in their design and construction, there is much to say in their favour. This includes:

- long life, sometimes as high as 100 years
- low maintenance costs
- "free" energy, once the system is operating.

While each hydro installation is unique, requiring a design and construction tailored to the specific site, there are certain common elements. A typical micro hydro installation is made up of a turbine, a generator, and a control mechanism. These are generally housed together in a powerhouse.

Other components include a dam, a penstock or pipeline to deliver water to the turbine, a trashrack to filter debris, a trailrace to return water from the powerhouse to the stream, and electrical lines to deliver power to its destination.

To intelligently plan a micro hydro system at a particular site, one needs to know the water head available, the number of kilowatt hours required, the peak electrical power demand, and the minimum, maximum, and average annual water flows.

Water head refers to the distance through which the water can be made to fall. In the case of micro hydro, this is the height from which water enters the intake pipe to where it leaves the powerhouse.

It is primarily the water flow and the water head that determine the type of turbine best suited for the site. There are two choices. Reaction turbines, called "Francis" or propeller turbines, are most efficient in a low head installation. Reaction turbines allow water to flow past the turbine blades, and use both the pressure and kinetic energy in the water to spin the turbine.

Impulse turbines of the "Pelton" design operate most efficiently with high water heads. Impulse turbines use a high velocity stream of water to spin the blades. By varying the diameter and number of water jets, a wide range of flow conditions can be accommodated.

The cross flow turbine is a modern adaptation of the impulse design. It incorporates a movable guide vane which permits efficient operation over a wide range of flows.

Micro hydro generators can produce either alternating or direct current. The size and type you choose depends on the peak electrical power demand, the desired system capacity, and the annual variations in water flow.

Alternating current generators must be sized accurately to meet peak electrical demands, since there is no convenient method of storing AC current. They also require a governor to keep them rotating at a constant speed. Any variation in the AC generator's rotation will cause the current's frequency to deviate from the 60 cycles/110 volts required by most household appliances.

Direct current generators do not require a governor and can store electricity in battery banks. However, a DC-AC inverter is required if 110 volt AC equipment or appliances are to be used. DC generators perform better than AC generators at sites with a wide variation in annual water flow.

Information on obtaining water rights is available from the provincial Department of Environment.

Hans Weber's project is designed to improve an existing micro hydro installation, while Keith Merrill's is the restoration of an existing mill.

In recent years, several micro hydro projects have been successfully completed in Nova Scotia. The most widely known is Neal Livingston's 5 kw installation in Mabou. A four-page summary of Mr. Livingston's installation is available from the Department of Mines and Energy.

The province has also undertaken or supported the restoration of several water powered mills; these are now open to the public as museums.

Restoration of a Hydro-Powered Oar Mill

Keith Merrill
Crousetown, Lunenburg County

Purpose:
The mill is being restored for two reasons. It will produce winter employment for wood workers who are often unemployed during this time of year and it will serve to educate the public in the operation and history of small scale water powered mills.

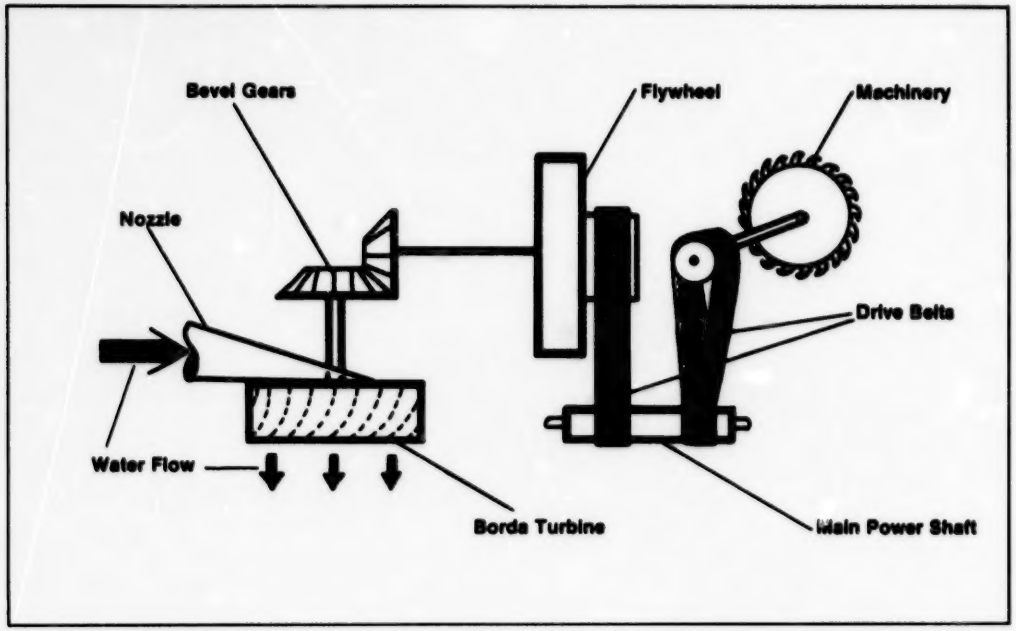
Description:
The heart of the mill is a *Borda* type, vertical axis, enclosed waterwheel. This drives a main power shaft through a series of wooden-toothed, bevel gears, and a wooden flywheel and flat belts. Each machine in the mill is powered by a belt connected to the main power shaft. The machinery consists of four saws, three planers, a belt sander, a dust blower, a conventional lathe, a copy lathe, an oar lathe, and a water pump for fire fighting.

The restoration began by replacing the support posts under the mill structure. Next the dam, sluice, penstock, nozzle and cylinder box were repaired or rebuilt. Then the flat drive belts were replaced and each piece of machinery overhauled.

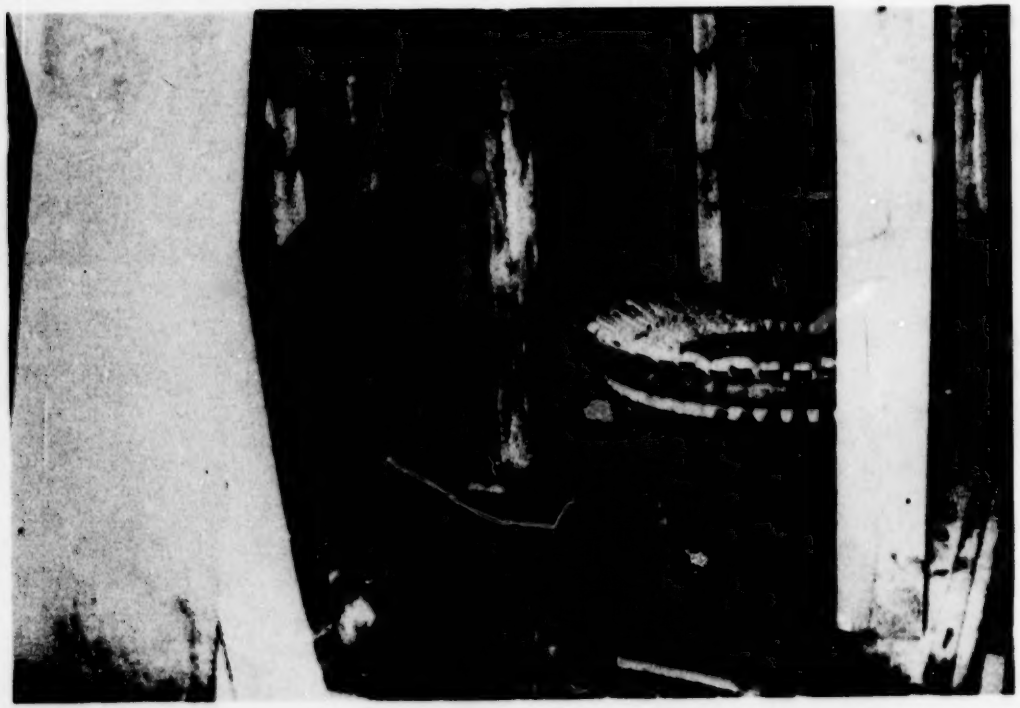
The machinery in the mill had been properly moth-balled and was in good condition. While fitting the new drive belts, Mr. Merrill learned how the belts stretch with use and change length with changes in the weather. Local residents who once worked in the mill helped with the restoration details and operation of the equipment.

Mr. Merrill hopes to install a modern turbine

Oar Mill with Dam and Penstock (right)



Schematic of Water Powered Oar Mill



Wooden Gears Inside Mill

and generator that would run continuously and produce electricity for light, heat, and wood drying.

Performance:

The building and machinery restoration is completed, and the mill started producing specialty oars (curved blades, laminations, odd sizes) in early 1982. The mill can also produce handles for axes, picks, shovels, and hoes.

Economics and Energy Demand:

Mr. Merrill started the mill restoration before receiving a Small Scale Energy Demonstration Program grant. He had already spent $3,400 on the dam, building and waterwheel. The grant of $2,200 was used to buy and install the drive belts. Additional money will be spent on the generator unit.

The mill requires no outside energy input; however, it is unheated. Mr. Merrill doesn't want to burn scrap wood for heat due to the fire hazard. When the electric generator is installed, it will provide electric heat and light.

Comments:

The oar mill is an excellent example of Nova Scotia craftsmanship. The turbine and all the machinery except for the copy lathe and bandsaw were built locally. Castings and machined parts were made in nearby Lunenburg or Bridgewater. Many mechanical parts are wooden and were built on site.

Viewing:

Those people interested in discussing the project with Mr. Merrill should telephone to make arrangements—**688-2353** or **688-2351.**

Refinement & Completion of a Small Hydro-Electric Installation

Hans Weber
Sydney Forks, Cape Breton County

Purpose:

A small Ossberger (Michell-Banki) cross flow turbine had already been built and installed in an earth and log dam. The present project involves:

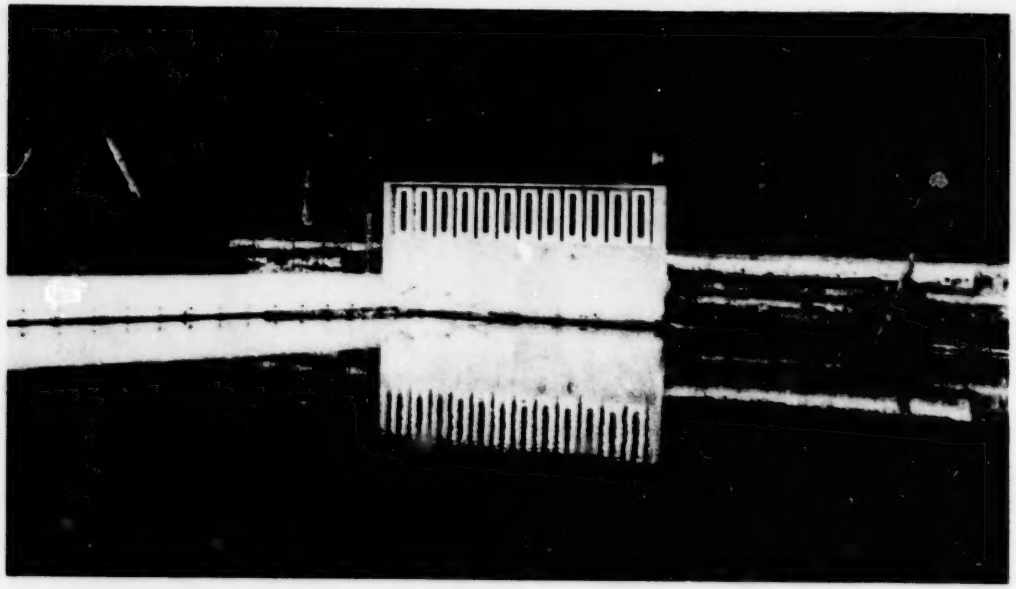
- enlarging the reservoir to minimize seasonal fluctuations in the brook flow
- constructing a concrete retaining wall to minimize leakage into the generator room and to reinforce the existing dam
- constructing an overflow sluice to divert excess water during the spring
- installing new electrical generation equipment.

Electricity generated by the turbine will be used in a new home to be built on the edge of the dam. Lighting will all be 12 volt DC and an inverter will create 115 volt AC for electrical appliances.

Description:

Mr. Weber excavated a 1760 m^3 (2,000 cu. yd.) pond in the path of a small brook. On the downstream side he built an earthen dam with a bridge section. Within the bridge is a generator room with a concrete penstock and a concrete floor.

The home-built cross flow turbine has a 300 mm (12 in.) diameter rotor with 24, 20 cm (8 in.) wide blades spaced at 15 degree



View of dam across pond

intervals. Each blade is made from a quarter section of a 100 mm (4 in.) steel pipe. Mr. Weber welded the runner and shaft together and then had a local machine shop turn the assembly on a lathe to make it "run true" and balance it.

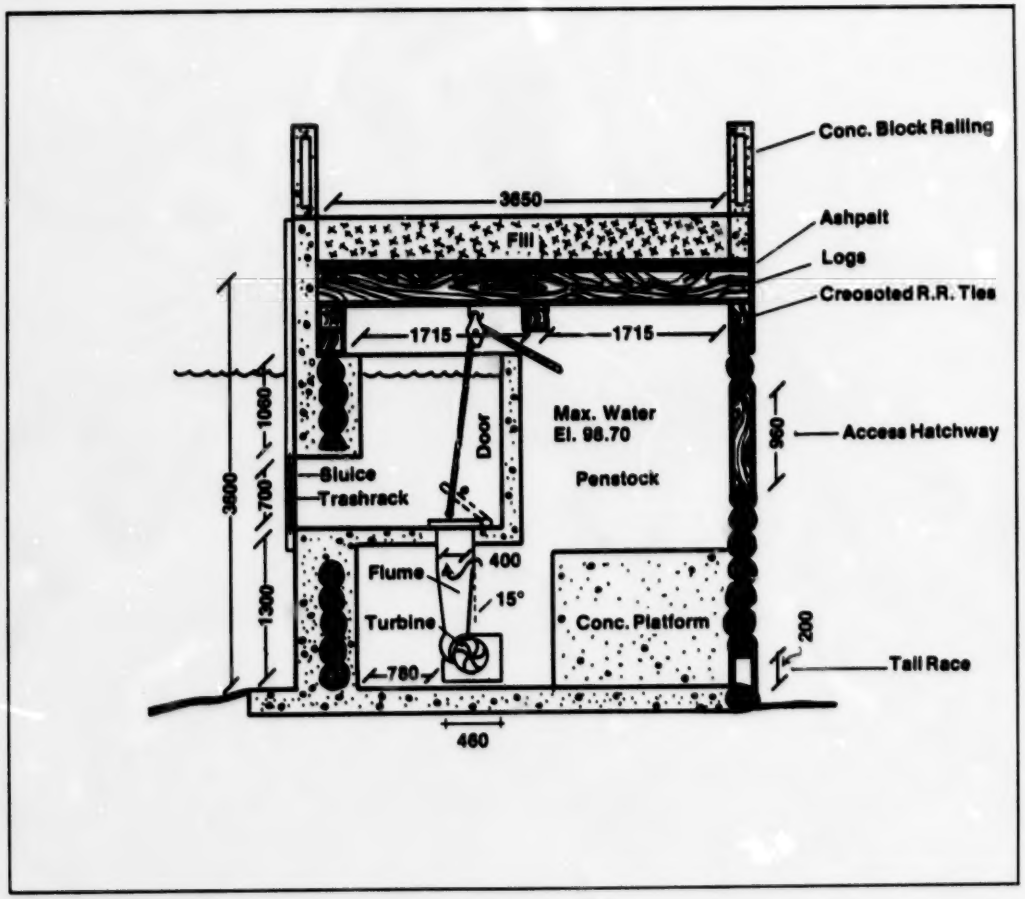
Water flows from the concrete penstock, through a steel plate flume, to the turbine runner. After passing through the runner, the water spills onto the concrete generator room floor and then out the tailrace and back to the brook. A door with a watertight seal was placed on the bottom of the penstock to stop the water flow to the flume and turbine for maintenance shut-downs. A sluice gate with a trashrack is

mounted at the entrance to the penstock. It controls water flow to the turbine and keeps debris out.

The bridge and generator room were initially made of logs and earth, but water continuously leaked through the walls, making the room too wet for a generator installation. The face of the dam has now been covered with a reinforced concrete wall, making the generator room considerably dryer.

The reservoir has been excavated to 5280 m^2 (6,000 cu. yd.). The material from the excavation has been used to extend the dam to surround the enlarged reservoir. A 100 amp., 12 volt *Delco* alternator was fitted to the output shaft of the turbine using a V-belt drive. This electricity is fed to a bank of 16 batteries.

A float device with two limit switches determines when the water is about to overflow the spillway. At that point, a 12 volt motor is energized. The reversible motor turns a power screw that opens the door, permitting water flow to the turbine. When the door is fully open, the regulator is energized and the alternator starts producing power.



Cross-section of dam with powerhouse

When the water level behind the dam falls to a non-productive level, the second limit switch on the float mechanism energizes and reverses the power screw motor, closing the hatch and stopping the turbine.

When the water level behind the dam rises again, the process will be repeated. A mechanical voltage regulator determines if the batteries are fully charged. If so, it overrides the command to open the door, allowing the water to flow over the spillway.

Performance and Cost:

At present, Mr. Weber has little use for the power generated by the hydro system. He intends to build a house beside the dam which will have designated 12 volt electric circuits. He will also be adding a mechanical inverter for operating kitchen appliances. In the meantime, the hydro-generated electricity is used for outdoor lighting.

The time and duration of generating cycles depends on the seasonal flow of the supply stream. In the spring, the pond fills in three or four hours and the turbine runs for eight to ten hours at a time. During the summer, with less flow in the stream, the system cycles only once a day. This seasonal flow should match the increased lighting demand of the winter months.

Mitchell-Banki Turbine

The present set of batteries is quite old. A new set would charge more easily and hold the charge longer.

It is difficult for Mr. Weber to determine his actual costs; many second-hand materials were used and much of the work was done over a number of years. To the best of his knowledge, the project has cost about $7,000.

Viewing:

Anyone interested in viewing the project should call Mr. Weber to make arrangements—**564-5620.**

One of a Kind

8

The projects described in the following pages are unique among those sponsored by the Small Scale Energy Demonstration Grant Program. Because of their uniqueness, they have been grouped together in this special "One of a Kind" section.

The projects—a solar lumber kiln, a solar crop dryer, a wood gasifier, a blueberry mower, and a wood heated greenhouse—all use technology that was uncommon in Nova Scotia at the time they were proposed.

The originators of these projects exhibited a willingness to experiment with new ideas and with new ways of doing things. Along the way, they demonstrated an ability to overcome unforeseen technical challenges and complete what they had begun. The usefulness of their projects will be either proven or disproven in time.

To encourage low cost projects that are original and interesting, that save energy or utilize renewable energy, is one objective of the Small Scale Energy Demonstration Grant Program. These projects are an important part of the realization of that objective.

Solar Heated Lumber Kiln

Alan Comfort
Port Medway, Queens County

Purpose:

The operator of a woodworking shop, Mr. Comfort is interested in drying locally produced, furniture grade lumber at a minimum cost. Air-dried lumber suffers from surface degradation, while commercially dried lumber costs three times more than local green lumber. The solar kiln is intended to dry 1500 board ft. of lumber, using fans to circulate solar heated air through the wood.

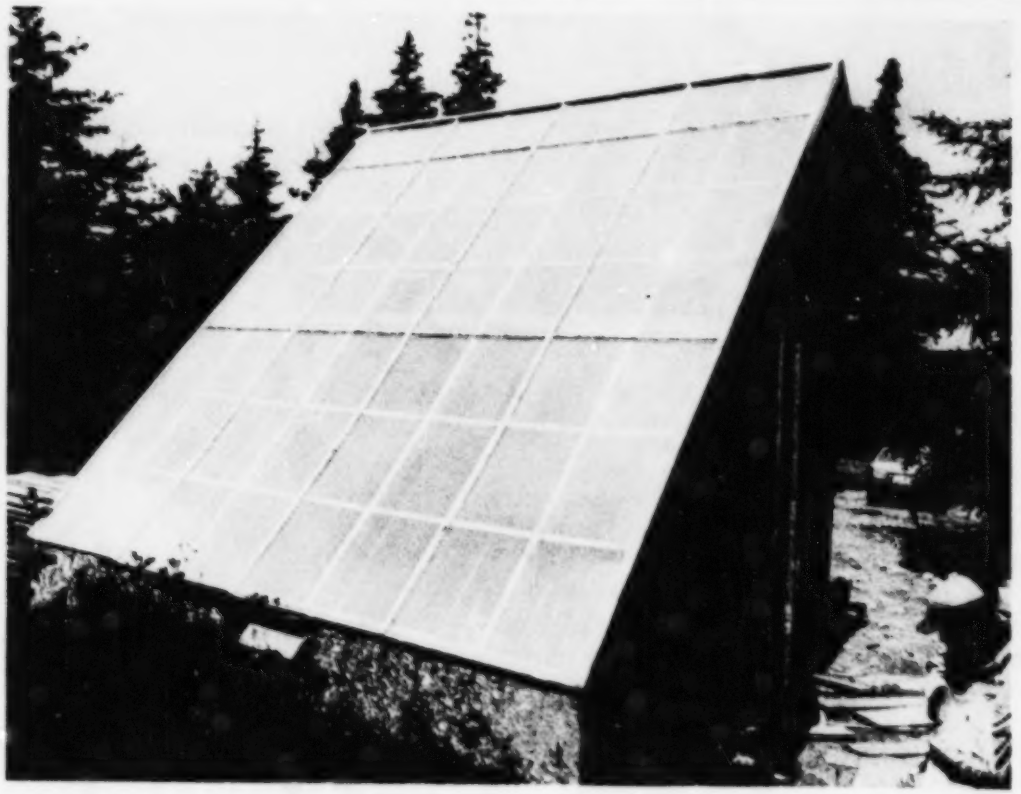
Description:

The kiln building measures 4.4 m x 5.0 m (14 ft. x 16 ft.). It has a right-triangle cross-sectional shape. The wood is placed in stickered piles in the rear room. Two box-type solar collectors heat air that is then blown through the piled wood by two fans. The air then returns to the collectors.

The building stands on concrete posts with footings below the frostline. The posts are positioned to support the heavy weight of 1500 board ft. of green lumber, so they are not all at the corners of the structure.

The floor joists and rear wall are built of 50 mm x 150 mm (2 in. x 6 in.) lumber while the rest of the framing is 50 mm x 100 mm (2 in. x 4 in.) lumber. The wall and floor cavities are filled with fibreglass insulation and covered with a 6 mil. vapour barrier.

The interior wall partitions are framed with metal studs and covered with galvanized sheet steel. Steel was chosen because it will not degrade when exposed to high humidity and temperature. Inside the collectors, the steel is painted flat black to increase its absorption qualities.

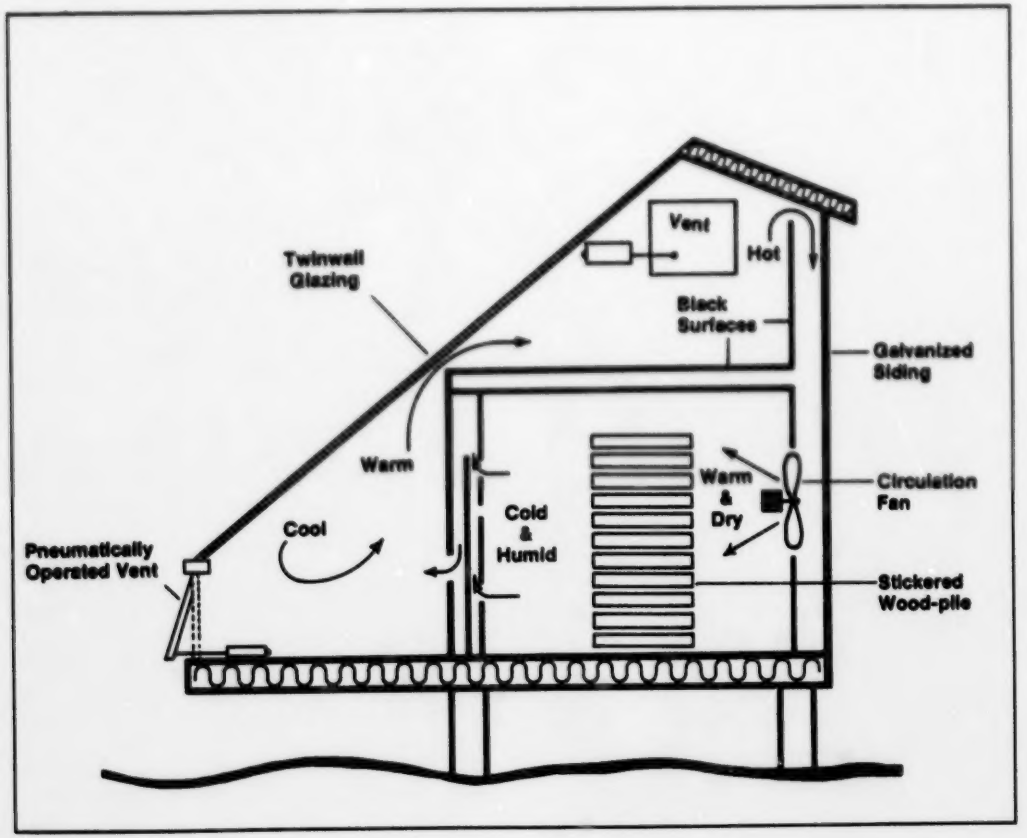


Solar Kiln from glazed side

As the air is heated, it rises naturally to the top of the second collector. From there, the fans draw the warm air down through the stud wall cavity into the drying room. The air passes through the wood pile, picking up moisture, and then returns to the collector through the wall opposite the fans. This wall has a circulation trap, which reduces reverse thermosyphoning at night (warm wood heating the air and causing it to flow backwards through the collectors).

A vent in the knee-wall allows fresh outside air in, while two vents in the side walls, near the peak, allow stale, humid air out. An over-heat thermostat and a humidistat control the pneumatic system that opens and closes the vents as required.

Translucent panels of *"Twinwall"* double layer, acrylic glazing are secured to the framing with beveled strips and brass screws. Silicon caulking is the sealant. Mr. Comfort developed the clever idea of passing air over a cold metal surface to condense some of the moisture it holds. This reduces the air's relative humidity and improves its drying ability. Unfortunately, in this system the heated air passes directly over the cold metal before it dries the wood. Mr. Comfort realizes that the system could be improved if the condensing takes place after the air has passed through the wood. If this system



Cross-section of Solar Kiln

doesn't perform well, air flow may be reversed but this could decrease solar performance. The building could also be modified, although not costly, this solution could be quite inconvenient.

Performance:

As of January 1982, the system was not fully operational due to problems with the electrical wiring. Mr. Comfort expected these to be solved within one month.

The total cost for the kiln was just over $5,000. A grant of $4,670 was given under the Small Scale Energy Demonstration Program. The kiln should pay for itself within one year, based on the savings of drying local lumber as compared to purchasing the commercially dried product.

The kiln should dry three or four loads of wood per year. That number will depend on kiln performance, the weather, and the wood being dried.

As you might well expect from a wood craftsman, the quality of workmanship in the kiln is high.

Viewing:

Persons wishing to view and discuss the kiln with Mr. Comfort should telephone to make arrangements—**677-2560.**

Large Scale Wood Heat

John D. Curphy
Pleasantfield, Queens County

Purpose:

The Curphys have built a 446.4 m^2 (4,800 sq. ft.) greenhouse using passive solar energy conserving techniques. Since they plan to operate the greenhouse year round, they propose to add a wood-fired, hot air furnace capable of carrying the full heating load of the greenhouse during winter.

Description:

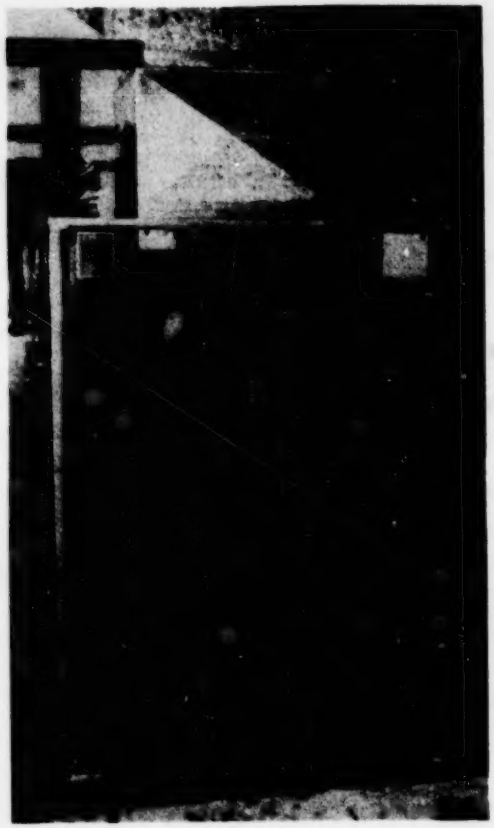
The 50 m x 9.4 m (160 ft. x 30 ft.) greenhouse was built with its glazed long side facing south and its north wall was insulated. The south wall is inclined at about 45° while the north wall is on a steeper angle of about 30° from the vertical. Both walls meet at the peak, so the building has no roof to speak of.

The greenhouse floor consists of about 600 mm (2 ft.) of large crushed stone for heat storage. Hot air from the peak of the roof can be forced down into the rock, which will radiate heat into the greenhouse.

Large greenhouse fans in the west wall provide summer cooling. The present glazing consists of UV resistant polyethylene plastic to be replaced with something more lasting when finances permit.

Heat loss calculations for this building showed it would require a heating system capable of delivering 350,000 BTU/hr (102 kw). Since the Curphys own 32.4 hectares (80 acres) of woodland, they wanted to heat the greenhouse with the cuttings from the land as part of a woodlot management program.

They chose to use a 500,000 BTU (145 kw)



500,000 BTU/hr Wood Furnace

Lynndale hot air furnace, since it was the only single unit of this size they could find. The furnace is of airtight construction with fan induced draughts for primary and secondary combustion. It can be loaded with 1.25 m (4 ft.) logs and will require three loadings per day.

In the event of a power failure, a bypass (the same one used for loading) will open to exhaust the combustion gases before they reach the secondary combustion chamber. This prevents the unit from overheating and also prevents excessive creosote buildup while the fan is out of operation.

Metal duct work carries the hot air to the greenhouse where the air enters a 48.8 m (160 ft.) suspended plastic duct to carry it the length of the greenhouse. This plastic duct is inexpensive, transparent, and can be easily removed during the summer.

The *"Selkirk Sentinel"* brand prefabricated chimney used can endure successive chimney fires without igniting the surrounding structure. When using a prefabricated chimney, check to see what it is approved for. Many CSA approved units were never intended for use with a wood burning system.

Performance & Economics:

The Curphy greenhouse only had passive solar heating before this wood system was added. As such, without insulating curtains, vegetables could not be grown all winter.

Calculations show that the greenhouse will require about 15 cords of mixed wood per year. Since the Cruphys will be cutting the wood as part of their woodlot management, the only cost is the additional effort required to drag it out of the woods.

The furnace itself cost $4,250 U.S., plus $580 U.S. for shipping to the border. Installed and operational, the system cost about $8,000.

Viewing:

Persons interested in seeing the system should call John Curphy, **685-2849**, to make arrangements.

Energy Conserving Blueberry Cultivation

Murray Fife
Southampton, Cumberland County

Purpose:

It is common blueberry farming practice to burn the blueberry bushes every two years with an oil-fired burner in order to promote new bush growth. Mr. Fife proposes to use mowing machines to cut the bushes rather than burning them, thereby saving the large amount of oil required by oil-fired burners.

Description:

Blueberry farms in Nova Scotia, New Brunswick, Prince Edward Island, and Maine are burned every second year to promote the new growth and development of fruit buds. The burning is done with a special oil burner that uses 115 L to 160 L (25 to 35 gal.) of Number 2 fuel oil per acre. Straw and hay are also used as fuel, but less frequently, due to their high cost.

At the University of Maine, researchers have used flail type mowers to cut the blueberry bushes. Their tests show that mowing works as well as, or possibly better than burning, provided that the bushes are cut within 19 mm (3/4 in.) of the ground and the mowing is followed by the usual fertilizer and herbicide spraying.

If the bushes are cut in the fall, the fractured bush stem is killed by the freezing winter weather causing the new growth to occur from the roots. The fields are also dry enough in the fall to support a tractor and equipment.

Blueberry Mower Attached to Tractor

Mr. Fife is using three *"Mott"* flail mowers in a gang connection. A 1.5 m (5 ft.) mower is connected to the tractor's 3-point hitch. Two 1 m (3 ft.) self-powered mowers 6 kw (8 hp) are towed from each end of the larger mower. This arrangement produces significant overlap and flexibility. It should enable the mowers to follow the contours of the berry field and ensure the required close cutting.

Flail mowers are used because of their ability to endure obstacles and clear themselves of debris. The small mowers required the simple modification of replacing their tires with a full width roller.

Performance:

The mowing system was not tried on blueberry fields until the fall of 1981. The results of this mowing will not be determined until Mr. Fife can examine the condition of the fruit buds in September 1982.

This mowing system is only useable on relatively smooth fields, specifically fields which were once ploughed.

In an early test of the mower cutting wild grass, it was apparent that slight modifications will be required. The engine on one of the rear mowers could be easily damaged by flying stones from the main mower. A rubber flap will be installed on the rear of the main mower and the engine of the rear mower will be repositioned. Both rear mower engines will be exposed to very dusty conditions so modification may have to be made to their air filters.

Economics:

On blueberry fields, which are suitable for mowing (approximately 23 per cent of the total Nova Scotia blueberry acreage), the mowers will save the 115 L to 160 L (25 to 35 gal.) of heating oil per acre that would have been consumed by burners.

A tractor is required for both this mowing system and for the burners. The additional 6 kw (8 hp) engines used for mowing do not burn an appreciable amount of fuel per acre.

Mr. Fife will be able to complete this mowing system for $5,700, including the cost of required modifications. The value of mowing has been proven in Maine. Mr. Fife could not afford the cost of this experiment without assistance from the Small Scale Energy Demonstration Program. If the system proves successful for Mr. Fife, the oil savings should make the system economically attractive on economic grounds to other blueberry farmers.

Viewing:

Blueberry farmers are welcome to discuss the conservation project with Mr. Fife. His number is **546-2647.**

Solar Crop Drying

David Firth
Lorneville, Cumberland County

Purpose:

The objective here is to develop an inexpensive solar collector to heat air for drying farm crops. It is common farm practice to use a fan for drying crops such as hay. In this project, air will be heated by the sun in a tent-like structure and then blown through the crop. Heating lowers the air's relative humidity and should substantially reduce the required drying time.

In the first stage of this project, materials were tested for the tent structure. Different fabrics were compared for their solar energy absorption rate and their heat transfer properties. In the second phase, a full-size collector will be built and tested.

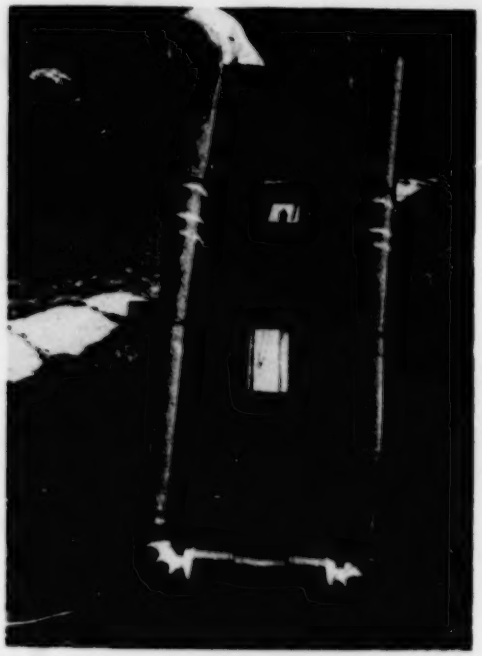
Description:

1st Phase

The apparatus used to determine the temperature gains of each fabric consists of two separate sheet metal ducts with a fan at one end and the test sample at the other. The sun's energy heats the air as it is drawn through the fabric. A white control sample is used on the end of one duct and the dark test sample on the other. The temperature difference between the air in the two ducts indicates how the test sample is as a collector material.

The sample is stretched over the top end of the duct. Beneath it, inside the duct, is half of a 10 junction, thermocouple (the other half is in the other duct). Downstream from the thermocouple is a sharp edged orfice followed by a butterfly damper. At the bottom of the duct, sits a scroll-type blower.

Kerosene differential monometers determine the air flow rate in each duct by measuring the pressure drop across the orfice plate. The butterfly damper can be adjusted to give the same air flow in each duct.



Fabric Absorbtion Test Apparatus

A normal test run would proceed as follows. The test sample fabric is stretched over the mouth of one duct and the standard sample is stretched over the other. The apparatus is positioned so that the samples are perpendicular to the sun's rays. The blowers are turned on and the dampers adjusted to obtain equal air flow in each duct. When the system has settled down, the temperature difference between the test sample airstream and the standard airstream is recorded. The sample is then switched from one duct to the other and the temperature difference readings repeated. This cancels any differences in the duct air flow and instrumentation.

Phase Two

Full-scale testing is awaiting the construction of a new pole style barn. When the existing traditional barn fell into disrepair, Mr. Firth decided to build a modern style barn which would incorporate a central fan and duct system for crop drying.

A tent-like collector measuring about 100 m^2 (1,000 sq. ft.) will be set up on the south end of the barn. The crop drying fan will draw its air through the collectors' fabric surface and flow the heated air through the crop. The lower relative humidity of the heated air will aid the drying capability of the fan system.

Performance:

The test apparatus was completed and operational in June 1981. Some difficulties were encountered sizing the orfice plates. After a bit of trial-and-error, a size was found to give reasonable flow control. A gas expansion thermometer was used initially but found to require too much adjusting so the thermocouple system was adapted. As of June 1981, absorption data were being gathered. Full scale testing with crops was expected during the summer of 1983.

Viewing:

To discuss the project, telephone Mr. Firth at **667-4282.**

Mobile Wood Gasifier

Truro Welding and Steel
Debert, Colchester County

Purpose:

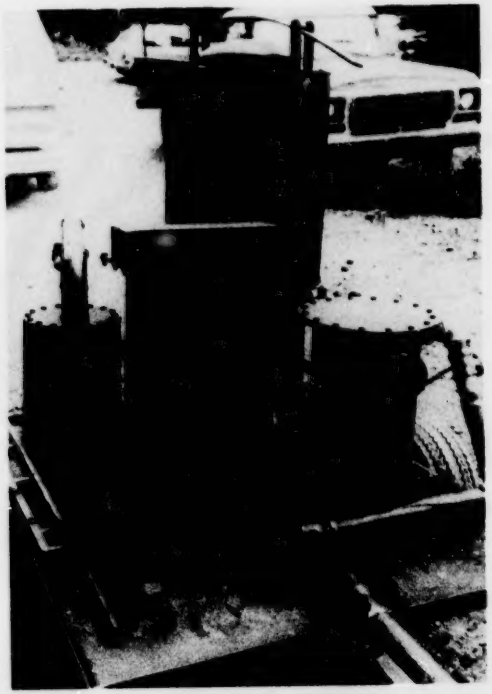
Keith Baas, the proprietor of Truro Welding and Steel, became interested in revitalizing the mobile wood gasifier concept, prevalent in Europe during World War II. His ideas encompassed boyhood fascination and a new product line for Truro Welding and Steel. The purpose of the project was to build a wood gasifier to power a farm tractor.

Description:

The initial plan was to purchase the rights to produce a German or Dutch farm tractor wood gasifier in Canada. Mr. Baas made contact with two European firms and, while both were initially receptive to the idea, as negotiations proceeded the price went beyond reason.

After two years of extensive investigation, Mr. Baas hired a Forestry Engineering graduate from the University of New Brunswick, Rich Creelman, to build a gasifier. During his university program, Mr. Creelman had already been involved in the construction of a gasifier to power a Volkswagon engine.

Wood gasification is a process where wood is decomposed at high temperatures in a deficiency of oxygen. The gas produced can be burned directly or cleaned and cooled for use in an internal combustion engine. It contains hydrogen, carbon monoxide, and methane carried in carbon dioxide and nitrogen. Liquids carried in the gas include acetone, methyl alcohol, acetic acid, oils and tars. These must be removed before the gas can be used in an engine. The final products of gasification are ash and charcoal.



Mobile Wood Gasifier on Trailer

The gasification takes place inside a cylindrical chamber. The wood chips are placed inside through a tightly sealed hatch. At the bottom of this chamber is a funnel shaped section made of stainless steel. Here the wood chips are heated and a small amount of oxygen is admitted. The hot gases produced during this partial combustion flow past the other side of the stainless steel funnel, heating the wood chips.

The gas, vapours and ash leave the gasifier and pass through a cyclone separator. This device causes the gas to swirl. Centrifugal force throws any ash particles to the outside where they slow down and settle to the bottom for later removal. Next, the gas and vapour pass through a cooler where the liquids condense. After a final filtration, the gas passes through the throttling valve to the engine carburetor.

The only modification to the 1600 cc (97 cubic in.) *Volkswagon* engine was the addition of a fuel shut-off valve in the gas line. The engine is started and stopped burning gasoline. This ensures easy starting and prevents creosote tar from building up on the cylinder walls. The entire gasifier assembly is mounted on a small trailer, towed behind the *Volkswagon Beetle.* A flexible hose and shut-off valve linkage connect the two.

Cost & Performance:

Mr. Baas and Truro Welding and Steel have spent over $11,000 on the project. Much of this was spent during the investigation stage. The gasifier materials and construction cost about $7,000. The gasifier works very well indeed. The only problem area seems to be the final air filter and Mr. Baas and Mr. Creelman are not sure if its necessary. The oil bath Volkswagon filter seems fine on its own.

The shut-off valve, which is kept closed during gasifier start-up, needs further work so that it can be easily operated from inside the car.

If the trailer does not vibrate sufficiently the wood chips will jam, blocking gas production. In stationary gasifiers a shaker grate is used to solve this problem and Mr. Baas may have to do the same.

The engine runs well on the gas, even starting on wood gas if stalled. Due to the energy content of the gas, the engine suffers an estimated 30 to 40 per cent power loss typical of these systems.

Comments:

As a result of Mr. Baas' extensive investigations into wood gasification, he has accumulated a vast knowledge on the subject. His reputation as a source of information is known across Canada and into the United States.

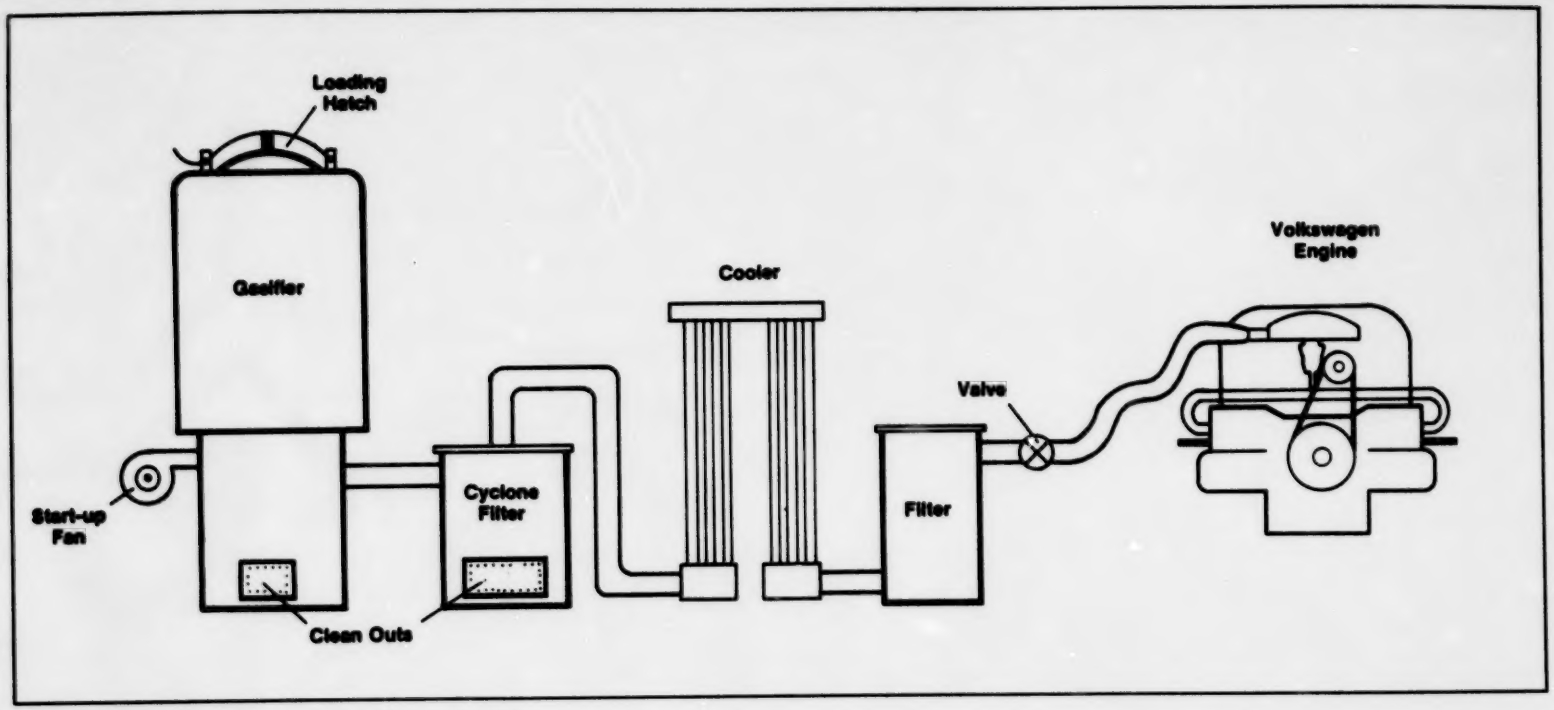


Diagram of Gasifier System

While the project has not yet resulted in any fabrication business for Truro Welding and Steel, there have been enquiries into using the gas directly for heating purposes in the maple sugar industry.

Viewing:

Persons wishing to view the gasifier should call in advance to mae arrangements with Mr. Bass—662-2401.